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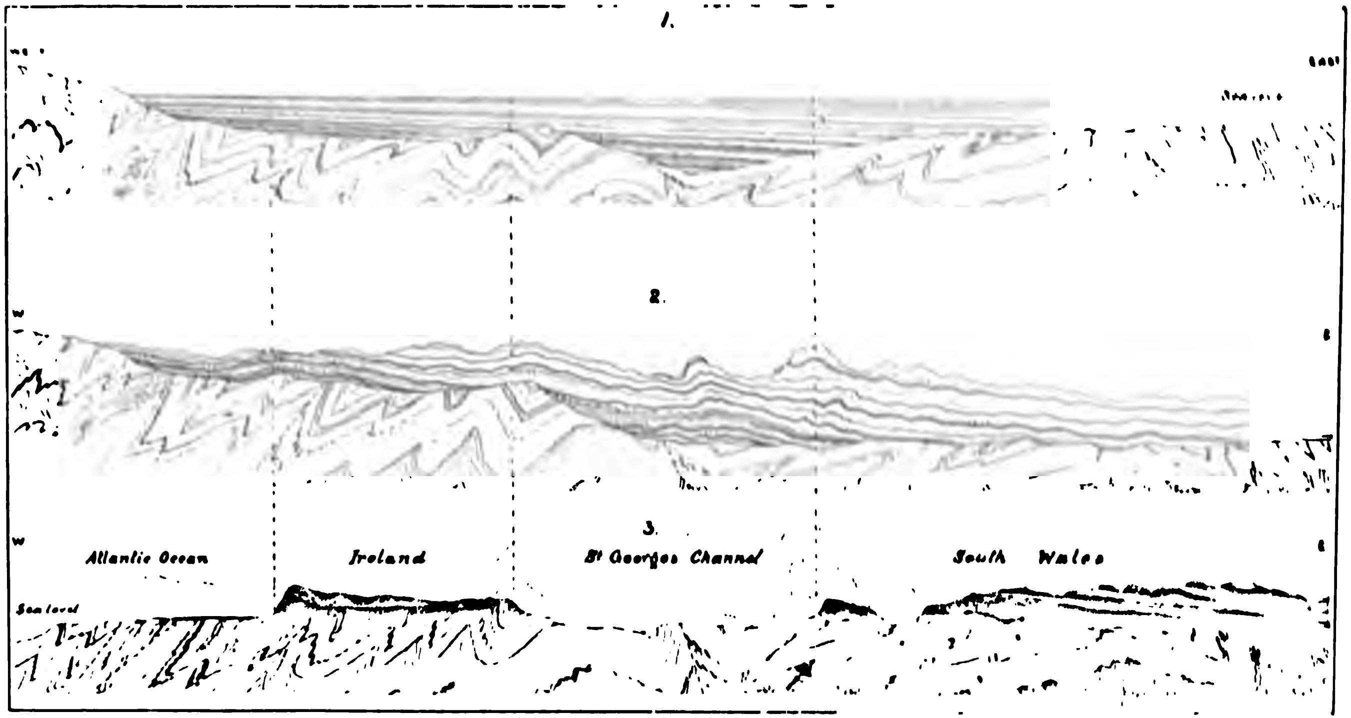

SECTIONS OF THE IRISH-SOUTH WALES COAL FIELD.

THE

AMERICAN GEOLOGIST.

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OBSERVATIONS REGARDING THE OCCURRENCE OF ANTHRACITE, WITH A NEW THEORY OF ITS ORIGIN.

By W. S. Gresley, F. G. S. (L. and A.), Erie, Pa.

(Plate I.)

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I. Stevenson's Theory of Pennsylvania Anthracite.

Dr. J. J. Stevenson has recently criticised all the leading theories* of the Pennsylvania anthracite and found them more or less wanting.† He then proclaims a novel one, considering it to explain observed facts. The author of the

*Except the electrical one propounded in 1870 by Mr. Joseph before the S. Wales Inst. of Engineers.
†Bull. Geol. Soc. Am., vol. 5, pp. 39-70, 1893.

present paper being practically acquainted with the anthracite region of Pennsylvania, as well as possessing some field and book knowledge of the principal anthracite fields of Europe, is induced to put his notes into tangible shape for the purpose of showing that the theory advanced by Dr. Stevenson does not sufficiently explain certain phenomena of anthracite regions, and of that of Pennsylvania in particular.

It may be well to state Dr. Stevenson's hypothesis briefly. He considers that the anthracite of Pennsylvania was originally vegetable matter similar to that of which the bituminous seams of the western part of that state are formed, but that the coal is not now bituminous because the accumulation of vegetable matter in the eastern area remained exposed for a longer period to the agencies which formed coal (before being covered up with sediment) than those of the western area. So that the inference is that Stevenson does not consider the partial metamorphism to which the anthracite series of Coal Measures have, as a whole, unquestionably been subjected, has been instrumental in converting the once bituminous coal into semi-anthracites and hard dry anthracites.

II. Evidences of Metamorphism in Pennsylvania Anthracite.

Now, the writer does not dispute a practically the same vegetable origin of anthracite as of bituminous coal. The first thing to consider is, what evidence is there that the Pennsylvania anthracite Coal Measures have undergone any metamorphosis? Aside from the general references made by Rogers, Dana, Le Conte, Lesley, Hunt and others in their manuals, text books, etc., the observations of the writer warrant him stating:

a. The fire clays of these coal regions are much more compact, less affected by weather, and heavier and tougher than those of the regions further to the west.

b. The shales (appropriately termed "slates") are very dense, hard and but little affected by exposure.

c. The sandstones and grits are exceedingly compact, tough and generally heavier and darker than in bituminous regions. Prof. T. G. Bonney reports observing a quasi-gneissic structure in specimens sent him.

d. The conglomerates—composed chiefly of white and gray quartz pebbles with a few of schist, slate, quartzite, etc.—are extremely compact and dense; occasionally the adjacent pebbles have been partially deformed or squeezed so that they are jammed into each other apparently without fracture. Through these conglomerates thin quartz veins sometimes run which pass right through the pebbles, the latter exhibiting a melted or fused appearance where incorporated in the veins.

e. The coals are very hard, compact, glassy and weather-resisting.

f. The clay-ironstone nodules are very tough, dense and hard. They contain distinct zones of mineralization, and crystalline pyrite similar to that found in similar nodules in the Alps is common in them. Their very dark color resembles both the Swiss and the Pembrokeshire nodules.

g. One characteristic of the fossils of this region is their black-leaded color or greasy metallic lustre, also observable in the slates of Rhode Island, Massachusetts and of the Alps.

h. The quantity of occluded gas existing in anthracite, considering its apparent freedom from interstices and cellar structure, is remarkable.

i. Carbon impregnation, such as streaks of graphite, and a more or less general pervasion of diffused blackening throughout the series.

j. Fine crystals of amethystine quartz have been found near Pittston, masses of lead and zinc ores in fissures in the coal beds near Scranton, smoky and clear quartz crystals near Tamaqua; very hard and brilliantly crystallized pyrite has been extensively found near Pittston.

Viewed as a whole these anthracite Coal Measures are of greater specific gravity, more crystalline, more siliceous, tougher, harder and darker than those of the western coal field of Pennsylvania.

III. Objections to Stevenson's Theory.

1. *Chemical considerations.* In order to agree with this theory facts ought to show that the percentage of volatiles in the anthracite decreases with the depth of the seam, i. e. the lowest bench of coal of any typical seam, other things being equal, ought to be lower in volatile matter and higher in fixed carbon than the uppermost bench; or that there is an apparent

gradation in chemical composition from top to bottom of the seam, debituminization having gone on longest and been strongest in the lowest layers. But published analyses do not reveal any such change that may be regarded as of any value in this connection.*

2. *Composite stratified character of Pennsylvania anthracite seams.* Stevenson seems to have based his theory on the assumption that the thickest and typical beds of anthracite were practically solid coal from floor to roof. Actual observations and measured detailed vertical sections in the mines and strippings reveal the fact that these typical coal beds are in reality split up horizontally into numerous alternate strata of coal and shale, coal and fire clay, or coal and sandstone or conglomerate, as the case may be,† so that each seam as a whole is really a parallel series of lesser seams, precisely similar in stratigraphical and structural character to the coal benches and their "dividing slates" of the "Pittsburg" bed in the bituminous region. The split-up character of anthracite beds in Pennsylvania could therefore hardly furnish Dr. Stevenson with the argument he uses in regard to the supposed longer exposure of accumulated coal material prior to burial beneath sand and mud. And a good reason is furnished for accounting for the practically uniform chemical composition of the various superimposed, yet separated, layers of coal in a seam, by the phenomena of the interstratified beds of shale, etc., just alluded to.

3. *Debituminization of coal a stage in metamorphosis.* As any stage in debituminization of a coal bed is to some extent metamorphism, the stage we designate anthracite is a stage in the metamorphic process. Graphite is probably metamorphosed anthracite, just as anthracite is metamorphosed bituminous coal, or bituminous coal is metamorphosed lignite. Mineralogists have not found it possible to establish any definite line or stage where metamorphism in rocks begins or yet ends in the direction of liquidity—molten rock. In like manner the fossil and mineralized vegetable matter of coals (no matter of what kinds of plants it is composed) presents no

*Cf. A. Ashburner: "Classification and Composition of Pennsylvania Anthracites," p. 19, 1886.

†Cf. 2d Geol. Survey Pa., vols. AC, A2, etc.

hard and fast lines for establishing a terminology; so that, just as the coarser as well as the finer grained inorganic strata of anthracite coal areas are found to be semi-metamorphic in character, i. e. in a transition stage between what may be called normal Coal Measures and decidedly metamorphosed strata of similar chemical composition, so should the coal seams they inclose be also regarded as semi-metamorphosed. There is no escape from such a conclusion; neither would there appear to be any necessity for investigators to go out of their way to seek an opposite theory of the origin of anthracitification. The point that seems to have puzzled us hitherto in accounting satisfactorily for Pennsylvania anthracite is that the crumpling, twisting and compacting of the Coal Measures of that region were not sufficient to produce anthracite, or that the conversion of the originally soft and bituminous coal was accomplished before the great upthrust of the Allegheny mountains took place, of which change we possess evidence.

4. *Anthracite, other than in seams, in the Coal Measures of Pennsylvania.* Besides the regular or irregular seams of anthracite coal in Pennsylvania the associated strata are rich in films or streaks of coal. These may or may not be detected as fossil bark of prostrate trees or in forms sufficiently definite to determine their exact nature; such stray or pocket deposits are known to miners as stringers, pipes, seeds, nests, plies, streaks, etc. Now, these extraneous unimportant (commercially) masses of coal in the Pennsylvania anthracite regions are not bituminous coal but anthracitic. They are apparently just as pure anthracite as are the beds or seams between which they lie. If, therefore, Stevenson's theory be conceded as applicable to the thicker or regular beds of anthracite, it must apply equally to these scattered filmy patches of the same material not in contact with the seams of coal; in other words, if it were necessary for vegetable matter to be longer exposed prior to burial by sediment in order to become anthracized, then every individual streak or lamina of anthracite embedded in shale and sandstone and presumably of vegetable origin must have been longer exposed ere sealing down by mud and sand ensued. We cannot admit the one and exclude the other; the mere dimensions of the masses of coal

under consideration do not affect the question of mode of formation or conversion of one kind of coal into another.

5. *Arenaceous or gravelly character of the Coal Measures of Pennsylvania.* A glance at the published columnar pit sections of the Pennsylvania Geological Survey (Anthracite regions) will reveal the well known fact that, taken as a whole, the Coal Measures are extraordinarily siliceous in composition, i. e. the bulk of the rocks are composed of sand grains, quartz and feldspar fragments and of rounded pebbles, the latter occasionally amounting to boulders in size.* Not only are the roofs of the coal seams frequently of conglomerate or grit, but the floors also, and even the "partings" in the coals here and there consist of quartzose grits, quite pebbly in places. Thus we find the character of the covering up or sealing down sediments of these anthracite beds is such that the process of their deposition points rather to one of rapidity, suddenness and depth or thickness, than to tardiness or a keeping back of roof-forming materials as soon as the respective accumulations of the vegetable matter were finished or ready for burial.

6. *Fish horizons on coal seams and their bearing upon the origin of Pennsylvania anthracite.* We may take it for granted that when a carbonaceous shale enclosing numerous fish remains, shells, etc., forms the uppermost layer of a bed of coal, as is very commonly the case, the inference is that the coal deposit was not suddenly and completely buried beneath sediments on the completion of the vegetable matter accumulation, otherwise no time or conditions would be allowed for the fauna to get there and occupy the waters for long periods, as they evidently did, before the invasions of mud or sand followed. No fish beds have been discovered or reported atop of any of the Pennsylvania anthracite seams.† And they seem to be just what Stevenson's theory would call for if his deferred burial of the coal material actually obtained in that portion of the Pennsylvania coal field. And when we get

*Cf. Trans. Man. Geol. Soc., vol. 22, pt. 2.

†The author has not even heard of any such animal remains ever noticed anywhere in the eastern Pennsylvania coal fields.

typical bituminous coal capped by fish beds* we almost possess just the conditions of deposition which Stevenson would apply to the anthracite region but scarcely look for in the non-anthracitic areas; so that, if the occurrence of fish beds is any index of delayed on-coming mud or sand deposits, then, on Stevenson's theory, the bituminous coal ought now to be anthracite and the now anthracite bituminous.

7. *Lamination or "grain" frequent in anthracite.* Had the vegetable accumulations really been unusually long exposed to the coal-forming process prior to sealing over by sand etc., as per theory of Stevenson, it seems not unlikely that the process would have caused the entire obliteration or extinction of the "grain" or horizontal lamination of the coal, in a manner somewhat analogous to modern peat, which we know loses its fibrous or original plant structure the older and the deeper it gets in the bog. That this anthracite of Pennsylvania possesses its original lamination structure is perhaps not so widely known or admitted as it deserves to be. As a matter of fact there are very few layers indeed (or hand specimens for that matter) to be picked up anywhere which do not clearly reveal this lamination when looked for; in fact much of it is as apparent and as sharply and as clearly preserved as the lamination or characteristic grain of the typical bituminous coal of the western coal field. Excepting for differences in fracture and lustre it is often difficult to tell specimens of anthracite and soft coal apart. The peculiar shelly and rugged fracture of anthracite and the oblique cleavage planes by which it is so generally broken up, make the grain of this coal comparatively obscure.

IV. Pennsylvania Anthracite had a Metamorphic Origin, but is not a Product of Folding.

It is perfectly clear, therefore, to my mind that whatever was the cause of the debituminization or anthracitification of the coal of the thick seams as well as of that upon the fossil plant remains, and the local scattered insignificant pockety patches or films and streaks of coal enclosed in the slates and sandstones, it was one and the same. And since the whole

*Cf. Bull. U. S. Geol. Sur., No., 65, 1891. The author has discovered a fish horizon on top of the main bench of the "Pittsburg coal." See Final Report Pa. Geol. Surv., vol. III, part 2—second footnote on page 2,452.

pile of the Coal Measures of the region are metamorphosed though not to the same extent, the contained coal in all its forms and at all horizons is more or less metamorphosed. The origin of the anthracite of Pennsylvania then was certainly a metamorphic one; and not due or confined only to the certain horizons—the beds of coal—as Stevenson seems to suggest.

The writer does not agree with those who suppose that the metamorphism apparent in the eastern Allegheny coal fields was principally a result of folding, crushing, thrust-pressures and of fissuring, which aided the escape of the volatiles of the coal: but he would venture to submit what he will call the hot water or hydrothermal theory, as possibly the most rational one yet advanced, or the one to which all the observed facts or phenomena of the region in Pennsylvania (and certain others besides) fit best. By hot water he does not mean to suggest that the Coal Measures and the coal seams were deposited in thermal waters, but that heated waters subsequently were instrumental in doing most of the observable metamorphism in a manner to be presently indicated.

V. Sequence of Geological Events Producing Pennsylvania Anthracite.

This theory will merely be stated generally or by way of a formal or working hypothesis, based on lines as broad as possible and compatible with the most recently advanced views bearing upon the fundamental and essential points in this connection. Attention is therefore directed to:

1. The Pennsylvania anthracite fields or basins, as is well known, consist of a rudely parallel series of plicated canoe-shaped troughs lying in still larger similarly shaped synclines of Sub-Carboniferous rocks of vast thickness (4,000 to 5,000 feet says Dana) and forming part of a series of very thick strata (30,000 feet) of still older formations now involved in the general elevated mountain chain of folded and crumpled rocks known as the Appalachian uplift. In reality the anthracite basins are outliers (or remnants of a once enormous coal region), which owe their preservation from total annihilation by denudation to their synclinal or pockety forms.

2. There are remnants of what was probably a great thickness of Permo-Carboniferous rocks in the anthracite region. These occur near Wilkes-Barre and near Pottsville, and

doubtless they were originally part of the same series of beds much more extensively preserved in the southwest corner of Pennsylvania.

3. We have already seen that the Coal Measures of the region in question are characterized by strata of sandstone, grit and conglomerate; shale and clays being comparatively unimportant, limestones still more so.

4. There can be no doubt but that as these Coal Measures were deposited by and in water they would be saturated thereby as the area of deposition subsided, and so would retain most of the water, just as the gravel beds, quicksands and sands do in estuaries and in valleys, or as the porous breccias, conglomerates and sandstones of the Permian and Triassic series in many European localities are heavily watered.

5. The coarse character of the strata implies a not distant coast or shore line or land, of course undergoing waste by erosion and denudation. Proximity to the shore coupled with coarseness of sediment also implies a relatively thicker vertical pile or series of Coal Measures than would be deposited further offshore and in deeper water and characterized by rocks of finer grain. The Pennsylvania Geological Survey computes the vertical thickness of Coal Measures in the center of the southern anthracite basin at about 4,000 feet, and for all we know this thickness was probably greater once, even greater further to the east and northeast.

6. The greater the vertical thickness of strata laid down in practically uniform succession one above another, the greater the subsidence of the area of deposition.

7. Strata-building must come to an end somewhere—sometime; and in the case of the Pennsylvania coal-area it is highly probable it ended with the Permian age, in other words the topmost or last-formed bed of that series (wherever it may have been deposited) was the proverbial straw that broke the camel's back; that is to say the weight and subsidence of the Paleozoic rocks had by that time become great enough to bring them within the limits or zone of sufficient interior earth-heat to produce a softening of them accompanied by some swelling or tendency to swell. The absence of Permian and Triassic rocks over the Coal Measures toward Ohio, Indiana, Missouri, and still farther west, and from what

was probably the Permo-Carboniferous in the anthracite region of Pennsylvania shows that there is reason to suppose that the mass above the anthracite coal was heavier than that above the bituminous coal.

8. On the supposition that this regional subsidence (produced by the vast thickness of rocks) was profound enough and maintained long enough to allow the rocks to be affected by this heat to such an extent or degree, as to materially raise the temperature of the included water, then the combined actions of heated and compressed waters upon the compacted rocks, would produce change in the physical and chemical conditions of the included coal beds.

9. The coal, its pores being saturated with waters of its accumulation, thus subjected to hot water under pressure, would, in all probability, gradually undergo debituminization, and acquire a denser or more homogeneous texture. The natural inference is that the lower beds would be the most altered, just as the rocks of the deepest part of the subsided region would become most metamorphosed.

10. A softening of strata means a weakening of it, and weakness leads to yielding or giving way.

11. In order that our softened and thereby weakened Coal Measures might yield or give way, the only direction in which movement would be possible would be upwards or away from the seat of metamorphism; a bulging upwards might therefore be expected to follow.

12. Accompanying this upswelling of the rocks would be subaërial denundation, and in conjuction with the assumed lateral thrust given to the rising mass of rocks by the bordering and perhaps now subsiding land, it seems proper to suppose that severe folding and rapid elevation into mountains would take place. Once the region began to rise, weakness would induce plication, plication and elevation would produce shrinkage, cracking, cooling, and extensive wearing away would accompany these processes. It is highly probable that mountain-forming or the elevating process would go on much faster than removal by denudation or erosion.

13. In the case of the Pennsylvania anthracite region it is supposed that the side-pressure on the uprising Coal Measures etc., was most severe or operated mainly from the east, thus

creating anticlines which have their steeper slopes facing the west, as is found to be the case.

14. The cooling off of the strata and the deep-seated or elevating pressures combined, would produce the jointing, fissuring, and all the observed slip-cleavage in the coal, etc.

Such then, is about the best or briefest description the author can give of the successive geologic events to which the anthracite in Pennsylvania is probably mainly due, and upon which we would look back as having brought this splendid fuel within our reach; for had the Coal Measures remained down there in plutonic regions, where the anthraciting process went on, the probabilities are man would have been unable to reach it. This coal then I claim, is essentially a product of the origin, cause, and process of mountain-making, i. e. internal heat acting upon water-soaked strata of vegetable matter and inorganic sediments, depressed far enough below the surface (prior to a necessary upheaval) to put the rocks through a process of "cooking"; which process of course operated more or less according to depth, kind, and amount of water, the variable character of the indivdual beds and local influences. Thus we find this anthracite is associated with the remnants of high mountains, composed of a great thickness of sedimentary rocks; the coal-seams being accompanied by sandy and pebbly strata originally filled with water, which water, on becoming heated, and kept hot long enough, was principally instrumental in changing the once bituminous coal into semi-anthracite and pure anthracite.

VI. Evidences of Former Hydrothermal Agency in the Region.

So much then for the theory. We will next see if there is any evidence in the region that internal heat of the earth was an agent in anthracite making. American geologists have reported no less than 56 hot springs occurring on the strike of the folded and twisted strata passing through the anthracite regions. That the origin of the lead and zinc ores, already mentioned as occurring in the anthracite, may be ascribed to ascensional thermal waters seems reasonable.*

*"Genesis of Ore-Deposits." by F. Posepny in Trans. Am. Inst. M. E., 1893.

VII. Anthracite Artificially Produced from Ordinary Coal.

In the Museum of Economic or Practical Geology, London, Eng., are (or were) samples of perfect anthracite, which were formed by Mr. Oakes at Alfreton Iron Works, Derbyshire. His process was heat applied to bituminous coal under pressure and presumably in a liquid medium, anthracite being the resulting product, not coke.

VIII. Wood Changed into Coal Hydrothermally.

Daubrée converted wood in water under pressure to a temperature of 575°F. into anthracite almost as hard as steel. Geikie cites "an example of the alteration of vegetable matter into coal by water, elevated temperature and pressure observed a few years ago in the Dorothea mine, Clauthal. Some of the timbers in a long disused level filled with slate rubbish and saturated by mine water, were found to have a leathery consistence when wet, but on exposure to air hardened to a firm coal, with the fracture of a black-glossy pitch-coal." The writer has an account of a peculiar discovery made in 1885 at a Spanish iron works. A large steam hammer and anvil, which had been erected nine years previously, had to undergo some repairs. On taking up the large blocks of oak beneath the anvil a considerable portion was found to be converted into a black carbonaceous substance not unlike anthracite. the process of conversion from wood to coal having evidently taken place by percolation of hot water aided by pressure or blows on the anvil. Again, E. S. Moffat* describes the alteration of portions of crushed props and wedges into true coal which had the characteristic cross-fracture, sharp and conchoidal, jet black in color, specific gravity 1.38 and a hardness the same as anthracite. These timbers were placed in an anthracite mine at Scranton, Pennsylvania, some 30 years previous to their discovered alteration. The place had been on fire for a long period and then deluged with water to put it out. The place where the timbers were was also filled with mine refuse, which being subsequently dug out revealed the carbonized timbers. Here then we have an instance of water heat and pressure converting vegetable matter into something

*"Note on the Formation of Coal from Mine timbers." Trans. Am. Inst. M. E., 1887.

closely resembling Carboniferous anthracite, and in an anthracite mine, a rather suggestive coincidence.

IX. The Anthracite Region of Pennsylvania a Typical One.

Now, we may certainly regard the anthracite region of Pennsylvania as a typical one. And if a satisfactory origin of *its* coal can be found it ought not to be difficult to account for anthracite in *other* regions. We will, therefore, follow up the inquiry in America and then cross over to Europe.

X. Other American Anthracite Regions.

In Tennessee and in Georgia semi-anthracite occurs. The thickness of the Coal Measures in Tennessee is great, but in Georgia denudation seems to have carried them almost away. In Tennessee we get conglomerates associated with the coals; and in Georgia, as far as they go, coarse strata predominate. Both in Tennessee and in Georgia the Coal Measures are folded and disturbed. In both these states the Carboniferous flanks or belongs to a mountainous range and is considered to have come within the influence of some metamorphism in past geologic ages.

In Arkansas the coals are said to get more anthracitic as traced or tested in an easterly direction.* Winslow and Macfarlane say that sandstones, shales and conglomerates make up almost the entire list of the rocks, and while folding and anthraciticism do not seem to be concurrent phenomena here, we have the Carboniferous undoubtedly underlain with Silurian and folded Huronian, because they come to the surface east, south and southwest of the coal field. Thus, although the physical geology of the coal region in Arkansas may be said to resemble that of the typical Pennsylvanian region, the characteristic features of the former are dwarfed into comparative obscurity. It is well known that the little crumpled and metamorphic outlying graphitic-anthracite field of Rhode Island and Massachusetts is bound up with rocks of a region characterized by foldings, faults and other evidences of deep-seated disturbances and alteration. The Coal Measures are decidedly conglomeratic and siliceous in character and probably originally extended into Pennsylvania, and so on west and south, and possessed a great thickness. Macfarlane and Dr.

*Ark. Geol. Surv. An. Report. 1888, vol. 3, Coal, p. 51.

R. W. Raymond refer to considerable anthracite in New Mexico. Whether the strata are or were once thick is uncertain, but sandstones abound in the series, the coals being tilted variously: the region is mountainous and contains unmistakable proof of vulcanicity or metamorphosis.

W. H. Merritt, F. G. S., of Toronto, Canada, informs me that he finds extensive areas of anthracite coal (originally lignites) associated with a preponderance of sandstone strata in the Canadian great Northwest. These coals are almost certainly of Cretaceous age, and occur between ranges of the Rocky mountains indicative of metamorphism.*

In Colorado there is anthracite; the Coal Measures are probably quite thick: they are folded and faulted; not far removed from igneous and metamorphic rocks and belong to a mountain system.

Prof. A. H. Green and E. Lane inform me that coal beds of a decidedly anthracitic character occur in Peru. They are stratified with sandstones, much crumpled and are adjacent to or incorporated in mountains.

Idaho possesses some anthracite, but its association with baked shales traversed by dykes places it in the category of the result of *local* or *contact metamorphism*, with which we are not now dealing.

Dr. H. M. Chance† reported that in the Indian Territory, which is south of Arkansas, the thickness of the Coal Measures is between 8,500 and 10,000 feet. The strata are markedly sandstones of massive character. The coals exhibit evidence of decided conversion in the direction of anthracite; the strata are considerably distorted into anticlines and troughs: the country is elevated if not mountainous, in fact, to quote Chance, "Topographically and structurally the Choctaw coal fields represent in miniature many of the features of the anthracite regions of Pennsylvania. The measures are flexed by a series of anticlinal and synclinal folds not usually as sharp as those of the anthracite, but in many respects very similar. While all the anthracite basins are surrounded by a

*"Notes on Some Coals in Western Canada," in Trans. Am. Mining Inst., vol. 18, p.,313.

†"Geology of the Choctaw Coal Field," in Trans. Am. Mining Inst., vol. 18, p. 653.

mountainous rim, of which the outcrop of the thick and massive conglomerates forms the core, the Choctaw basins are enclosed by a ridge, sharp and bold in places, but rarely mountainous, formed by the outcrop of the basal sandstone. Whether this rock is the equivalent of the Conglomerate or not is yet wholly conjectural." In this coal field analyses show the coal to be least anthracitic in the west and most so towards the Kavanaugh mountains on the east, in which direction also the greatest pile of Coal Measures occurs.

XI. European Anthracite Regions.

The Irish-South-Welsh coal field. That we have good grounds for supposing the southern Irish anthracitic basins were originally part of the South Wales coal field few if any will deny. Now, as is well-known, the anthracitic portions of the latter region and all the Irish anthracite is topographically and stratigrapically very similar, that is to say both are adjacent to or flank regions composed of pre-Carboniferous rocks of great vertical thickness, though now much folded and enormously planed down by denudation. The South Wales Coal Measures, and perhaps the Irish too, are characterized by thick and very numerous strata of sandstone and of grit.* Some 12,000 feet is the reported thickness of the Coal Measures in Glamorganshire. Is there any reason to suppose that this thickness was less where Pembrokeshire, Carniganshire, or the St. Georges channel now are? It is true the Devonian series thins out in a westerly direction below the South Wales coal field. Furthermore the Silurian, Cambrian and older rocks of this region of Great Britain are, in a sense, metamorphosed, and local streaks of anthracite are known to occur in the Silurian. A reference to the generalized sections herewith shows the author's idea as to where the greatest original thickness of Carboniferous rocks perhaps was, namely,—where the channel is now (see section No. 1). No. 3 shows Ireland and South Wales above sea level with the anthracitic regions as now remaining after the general upheaval and consequent crumpling and faulting (seen in section No. 2) and so largely removed where the curved dotted lines are in section 3. If my views in regard to these formations and changes be something like correct, then the inference is the thickest

*See Mem. Geol. Surv. of G. B., vol I, paper by De la Bèche.

pile of strata was in Pembrokeshire, Cardiganshire, or a little west of them, and therefore it was there that subsidence was greatest and most heat or maximum debituminization of the coal effected the marked siliceous or sandy character of the measures, aiding, by reason of its included water, the process, not a little. That the noted gradual change in the composition or kinds of coal of the South Wales basin will be in general agreement with the hydrothermal hypothesis now advanced seems probable. The deep-seated hydrothermal theory for anthracite would appear to furnish a reasonable explanation as to why, in the South Wales coal field, the lower coals, as followed east beneath the upper seams, become more bituminous. The theory also provides a reasonable explanation of the phenomenon of practically flat beds of pure anthracite as they occur in Ireland; a difficulty in accounting for which has we think hitherto been felt. Structurally then, there is little difference between the anthracite regions of Wales and Ireland and those of Pennsylvania; especially when the points of the compass have been reversed, because in Pennsylvania the change towards anthracite is in the opposite direction to what it is in Wales. However it all points to a continent in the North Atlantic region from which the Paleozoic strata were derived. and which perhaps operated principally in producing the great regional upthrust and puckerings of the earth-crust after the coal period.

That the Coal Measures in Devonshire and in Brittany, whose leading features may be said to be great thickness of sandy shales, sandstones, grit and compact gray quartzites,* with interstratified, though thin and unimportant (commercially) layers of anthracite, highly crumpled and often much altered (? metamorphosed), and depressed between elevated areas of older rocks—is significant in this investigation.

In passing, we should not forget the great thickness and sandstone characteristic of the Somersetshire coal field and its suggestive highly-disturbed southern border, along which, unless I mistake, the lowest coal beds are less bituminous than the higher and flatter seams.

Sir Arch. Geikie says "Some Lower Silurian shales are black from diffused anthracite."

*See De la Beche's report on Cornwall and Devon.

Prof. Thomas in "*Coal Mine Gases and Ventilation*," 1878, says,"the anthracites are derived probably from organic materials which become buried very rapidly under a considerable thickness of inorganic matter." In the coal basins of Mons, Valenciennes and Liege, the same coal beds which are decidedly bituminous (*gras*) near the surface gradually become anthracitic as traced downwards till they pass into true anthracites. In viewing these French and Belgian regions we should bear in mind how the Coal Measures are squeezed, rolled up and faulted against or by very great thicknesses of older strata, evidently thrust up from once very much deeper and warmer regions. A fault exists somewhere in the Pas de Calais coal fields with a throw of about 1,200 feet, the downcast side being towards the south. On each side of this fracture of displacement, at a depth of 900 feet or so, the percentages of volatiles in the coals was markedly different, those on the downthrow side having 28 to 30% as compared with only 12 to 18% in those on the upthrow side. This shows that the deeper the seams are the more anthracitic they get, and that the loss of volatiles was brought about before faulting occurred. That somewhat similar phenomena are to be met with in the deeper shafts of collieries in North Staffordshire, Cheshire, and Lancashire, the writer has reasons to believe, at all events the deepest seams, as a whole, approach the characteristics of anthracite more than the uppermost do.

In the Prades coal-field, France, M. Roussellier described the Coal Measures as reposing in a basin of the Ardèche crystalline rocks, those overlying and underlying the coal series being chiefly gneiss and mica-schist. The coals have variable dips, and locally, complete contortions are found. "The Coal Measures are chiefly composed of variable beds of sandstone and conglomerate, there being very little shale." The measures are about 350 metres thick. The field is said to be ruptured by a modern volcano, but which "has in no way altered the Coal Measures." "The coal is poor anthracite."

Prof. E. Hull wrote of the Asturias coal region in Spain, the chief features of which are "coals belonging to three classes, viz., anthracite, semi-bituminous and bituminous." The strata are thrown into high angles varying from 50° to 70° and the topography is decidedly hilly.

In Saxony we read of the association of conglomerates with anthracite.

In Hungary Liassic coals are reported to occur as semi-anthracite.

In Switzerland, Savoy, and Italy, anthracite occurs with schists and sandstones, considerably flexed and reposing on Silurian rocks. Gras says the thickness of the anthracite-bearing strata of the Alps was about 25,000 feet.

In Baden, the coal of Offenburg* is anthracite and is bedded in a zone of Carboniferous sandstone between the steep gneiss rocks at the mouth of the Kinzig valley. The coal beds dip at high angles and were originally thought to be *veins*.

In the Donetz region in Russia, A. Brüll informs us that on the southwest the coal field is bounded by crystalline formations; on the northwest the measures are highly inclined and covered by Permian beds. Sandstones are numerous and the seams of coal are anthracite. Prof. Hull. in his "Coal Fields of Great Britain," says, "It is a most remarkable circumstance in connection with the Donetz formation, that the same beds of coal, from being highly bituminous in the western part of the field, pass by imperceptible gradations into anthracite in the eastern parts in a manner analogous to that of the South Wales coal field in our own country. In the western or bituminous districts the coals are associated with limestones containing *Spirifer mosquensis*. Towards the center these calcareous beds tail out and are replaced by beds of sandstone and shale, which become hardened and altered as the coal seams become anthracitic.".

In the Province of Leon, Spain, Hausmann (in Q. J. G. S., vol. 7, part 2, p. 11) reports extensive coal beds of great thickness, much tilted and squeezed between highly inclined rocks (in a mountainous region) in a remarkable manner: moreover clay slates, sandstones and quartzites abound in the Coal Measures.

In the district of Oporto, Portugal, S. C. Ribeirs (in Q. J. G. S., vol. 19, part 2, p. 9) describes anthracite of more than one grade occurring in association with clay slates, breccias, sandstones and quartzites, with steep dips and metamorphic aspects.

*M. Ludwig, Q. J. G. S., vol. 14, p. 26 of notes.

XII. Asiatic and Other Anthracite Regions.

In Asia Minor, Spratt refers to semi-bituminous coals associated with shales, schists, sandstones and conglomerates of great thickness in a valley between high ranges of hills, the coal beds lying in folds, etc. (See Q. J. G. S., vol. 33, p. 524.)

The Singareni coal field, Hyderabad, India, (according to Mr. J. P. Kirkup) reposes in a basin or valley surrounded by metamorphic schists, etc. Its coal beds are bituminous towards the surface and semi-bituminous in depth. They are interstratified with sandstones and exhibit the usual faulting and bending up against the basal rocks, which are greatly eroded.

In Annam, at Nong-son, P. de Bure mentions coal of anthracite nature embedded in slaty sandstones, and having 50° inclination.

In India, in Sikkim, very coarse-grained Coal Measures occur, carrying seams of anthracite coal. The beds are much tilted and the region is adjacent to the Himalayas.

Again in China, good anthracite is reported to occur in the hill country not far from the sea coast. The seams are highly inclined and, as followed upwards in order of formation, are found to grade into semi-bituminous and strictly bituminous coals.

In New South Wales there are said to be about 11,000 feet of Coal Measures in the whole coal system. In the Lower Coal Measures (Greta series) semi-bituminous coal beds occur and conglomerates are by no means unknown.

In Tasmania we read "the sandstone cropped out with the coal at Port Arthur." "The first coal wrought in Tasmania was the anthracite of Port Arthur."

In Japan anthracite coals are stated to occur.

Alaska, Vancouver and Queen Charlotte islands are also reported to possess beds of fine anthracite.

XIII. Conclusion.

In regard to the hot water theory, it should be said that *high* heat was not necessary to convert bituminous coal into anthracite (Le Conte). Probably 300° to 400°F. would suffice to make the change. Daubrée found that when the waters of conversion were alkaline, it took less heat to accomplish metamorphosis; in other words, alkali or mineral waters aid

the process of anthracitification. Prof. A. H. Green has remarked that coal often becomes much more carbonized when its roof changes from a shale or clayey one to sandstone, a statement the author endorses from personal observation in coal mines, though of course there are exceptions. The author would submit that the reason why some benches of anthracite seams are locally more carbonized than others* is because the different benches were originally or subsequently not all equally water-soaked or similarly acted upon by the hydrodynamic influences to which they were differentially subjected. He also submits that the included water of the Coal Measures, when under thermal pressure, would be forcibly injected or diffused among and through the organic as well as the inorganic constituents of the strata to such a degree as would bring its action within layers or beds, under ordinary conditions, largely excluding it. And in regard to thrust-pressure, it is not likely that the pressures that were concerned in the folding, crushing and faulting of the anthracite Coal Measures were sufficient to create heat enough to still further anthracitize anthracite to an appreciable extent, assertions to the contrary by men of note notwithstanding. To the jamming and squeezing of plication and fracturing most of the "slips," "faces," "backs," "cutters," "joints," etc., of miners may be attributed.

In the author's paper entitled "Anthracite and Bituminous Coal Beds. An Attempt to throw some light upon the manner in which Anthracite was formed; or Contributions towards the Controversy regarding the Formation of Anthracite," read before the Geological Society of London, 25th January, 1893, and from the discussion that followed it, it appeared tolerably clear that the association of arenaceous strata and anthracite was something more than *accidental*. From a much wider range of observations I think we have now pretty thoroughly demonstrated this circumstance, thus showing that the almost world-wide proximity of the two materials is something more than a mere *coincidence*. And while I am prepared to believe that anthracite may have been produced by regional metamorphism in the absence of any considerable thickness of sandstones, etc., in some localities,

*"Classification and Composition of Pa. Anthracites," by C. A. Ashburner. 1886, p. 19.

such situations seem to be at present unknown, undescribed or comparatively insignificant—the exception rather than the rule.

Thus it seems reasonable to suppose that wherever strata carrying coal-seams (no matter of what geologic age) were accumulated over regions of great thickness of older sedimentary rocks, or where conditions favored or ultimately led to subsidence, followed by extensive and prolonged elevation, where the coals underwent partial metamorphosis, they were thrust up, enormously reduced in bulk by denuding agencies; the reason why they generally now occupy or are principally confined to elevated situations (stratigraphically) is explained.

If therefore extensive beds of anthracitic coal are not met with or do not exist in regions characterized by flat country and comparatively level strata,* the reason is because the Coal Measures are not in proximity to existing or extinct (eroded away) mountains, and do not overlie stratified rocks of excessive vertical thickness. Thus the origin of anthracite is connected with one of the greatest or most profound problems in physical and dynamical geognosy.

If there be anything to be gained *practically* from this theory it is that it is of little use looking for anthracite except in regions where mountains exist or were once upon a time a feature of the topography as the uptilted and eroded strata may be evidence of.

If my observations shall lead others to make further and closer investigation in this connection, with a view of substantiating or refuting my hot water theory for anthracite, and other collateral conclusions, and assisting to get at and establish the truth of the matter (so far as is permitted to us), the writer's aim will have been achieved. The elicitation of suggestions is respectfully invited and a wholesome criticism anticipated.

*E. g. Northumberland, Durham, York., Nott., Derbyshire, Ohio, Ind., Mich., Ill., &c.

SERIAL NOMENCLATURE OF THE CARBONIFEROUS.

By Charles R. Keyes, Jefferson City, Mo.

When the problem of subdividing the Carboniferous of the upper Mississippi valley came up for consideration, a few years ago, it was found that the limits ascribed to the commonly recognized divisions were not only unnatural ones but that they were not the same in different states or even in all parts of the same state. It was seen, however, that with some modification of the existing arrangements, in Iowa and Missouri particularly, all the strata of the upper Carboniferous could be grouped into two series corresponding in a general way to the "lower" and "upper" Coal Measures. It was then proposed to abandon the old names and to offer in their stead the geographic titles of Des Moines and Missouri.*

Since the two terms mentioned were first introduced into geological literature they have been extended to other parts of the region. In several cases, however, there appears to be some misconception regarding the original usage of the terms and their exact taxonomic rank. This misunderstanding of the real extent of the terms is particularly noticeable in two recently published articles, one on the lower portion of the Kansas Coal Measures† and the other on the upper part of the Carboniferous of the same state.‡ The accompanying note, however, is not intended as a criticism on the excellent work lately done in Kansas. It is rather a statement made at this time to correct certain erroneous expressions which do not appear to be confined entirely to those papers already published, and to point out more clearly than has been done the exact vertical extent of the formations and the relations of the Kansas divisions to those of the neighboring states.

It is well known that, on account of the great industrial value of the mineral deposits contained, the Coal Measures of the Mississippi valley were the first to receive special geological attention. Yet notwithstanding this fact it has only been of late years that satisfactory information has been obtained upon which to base a subdivision that is applicable to the entire Western Interior province. The local classifications, if

*Iowa Geol. Sur., vol. I, p. 85, 1893.
†Kansas Univ. Quart., vol. III, pp. 271-278, 1895.
‡Journal of Geology. vol. III, p. 800, 1895.

they may be so called. have been very general and very indefinite. In no way are any of them to be exactly parelleled with those of adjoining localities. Moreover they are perfectly arbitrary, with little or no attempt to delimit the formations either on natural, stratigraphical or faunal grounds. Of late, detailed investigations by different individuals have been going on over a large portion of the region, first in Iowa, then in Missouri and finally in Kansas, with some reconnaissance work in Nebraska, Indian Territory and Arkansas. A sufficient number of facts have now accumulated to indicate plainly the positions of the lines of demarkation between the principal larger divisions. These have been found to be well defined over the whole basin. Smaller subdivisions, which are of only local consequence and which differ widely in different localities, may be established later. Local members have been already named for the greater part of Kansas. Progress in the same direction has been made in Missouri and Iowa, though the naming of the minor' subdivisions has been deferred until a careful comparison in all the various aspects can be undertaken. The subdivisions of the Carboniferous heretofore usually recognized in the Western Interior basin are:

1. Permian.
2. Permo-Carboniferous.
3. Upper Coal Measures.
4. Middle Coal Measures.
5. Lower Coal Measures.
6. Lower Carboniferous.

The Carboniferous rocks of the world are commonly referred to one of three great classes: the Lower Carboniferous (Sub-Carboniferous), Carboniferous proper (Coal Measures), and the Permian. In the Mississippi basin only the first two of these have heretofore been considered as well marked divisions. The third and uppermost has claims to recognition west of the Missouri river, but it is doubtful whether in any of the region east of that stream this member exists. Although so important a formation in many parts of Europe, where all members of the Carboniferous were first studied and defined, the so-called Permian of the Mississippi province does not assume such great importance as a distinct geological division. In the region under consideration the beds referred to it occur in Oklahoma, Kansas and Nebraska.

In considering geological classifications for any region, great or small, it has come to be recognized of late years that no satisfactory arrangement can be established in accordance with any one standard of comparison yet devised. It can only be accomplished as the final outcome of a comparison of all groups of pertinent data, by an interpretation of all the branches of the physical history taken *ensemble*. Applying these principles to the region under consideration and weighing all the evidence derived from the different lines of testimony a basis is believed to be found that will furnish a natural and satisfactory classification of the strata that is applicable throughout the extent of the Western Interior basin. In the Carboniferous of the region there are recognizable three distinct classes of sediments: (1) the marginal or coastal deposits, (2) the strata laid down in the more open sea, and (3) the off-shore depositions. These form four series, which are so arranged that the off-shore sediments form the top and the two maritime formations are separated by the coastal deposits.

The four series are sharply contrasted. The first comprises heavy-bedded limestones, rich in marine fossils, but with comparatively little shale and scarcely any sandy material. The second series is characterized by rocks that are prevailingly sandy and clayey shales and sandstones with scarcely any limestone. The individual beds rarely have a wide geographical extent, but replace one another in rapid succession, both laterally and vertically. The fossils contained are largely brackish-water or shore species; remains of pelagic organisms are not numerous. These and many other phenomena attest a constantly shifting shore-line and shallow water. The third class of beds is composed largely of calcareous shales, with heavy and numerous strata of limestone. The clay shales and sandstones are practically absent. The individual layers, especially the limestones, are homogeneous and continuous over broad areas. The faunas are composed chiefly of the more strictly open sea forms. The fourth series is more closely related in its lithological features to the second, but the calcareous beds are more numerous, particularly in the lower part, and all the layers have much greater continuity. In the latter respect it approaches the third class.

It is proposed therefore to recognize in the "upper" Carboniferous of the Western Interior province three series having equal taxonomic rank. The entire Carboniferous of the region would be arranged as follows:

CARBONIFEROUS.
- Oklahoman.
- Missourian.
- Des Moines.
- Mississippian.

The Mississippian series is the basal portion of the Carboniferous. It is almost entirely composed of limestones and the more open sea depositions, which contrast sharply with the shore deposits superimposed upon them. A marked line of unconformity separates the two classes of deposits. From this line it includes all beds below to the Devonian. To this basal series of the Carboniferous the term "Subcarboniferous" was widely applied until recently, when the title "Lower Carboniferous" was substituted. The history of these names and their various applications has been so fully reviewed lately* that there is little to add. The title Mississippian† is a revival, with a slight terminal modification, of a name originally suggested by Alexander Winchell.‡

As a definite geological term the name Des Moines was proposed§ for the principal coal-bearing strata of Iowa and Missouri, embracing essentially what had been previously called the " lower " and " middle " Coal Measures. The name was given because the Des Moines river flowed, for a distance of more than 200 miles, directly through the area occupied by the beds of this age. Moreover, Owen ‖ had early applied the term of Des Moines coal field to the region, though without modern geological significance. The formation was defined as extending in a broad belt from north-central Iowa southward into Missouri, following around the northern and western flanks of the Ozark uplift into Kansas and Indian Territory. The designation was designed to apply to one of the main divisions of the Carboniferous, as is manifestly shown in dividing into two principal parts all the Coal Measures of

*Missouri Geol. Sur., vol. IV, pp. 43-44, 1894.

†Williams: Bull. U. S. Geol. Sur., no. 80, p. 135, 1891.

‡Proc. Am. Philos. Soc., vol. XI, p. 77, 1879.

§Mon. Rev. Iowa Weather Service, vol. IV, p. 3, 1893; and Iowa Geol. Sur., vol. I, p. 85, 1893.

‖Proc. American As. Ad. Sci., vol. V, pp. 47-50, 1851.

Iowa and Missouri. Although minor subdivisions had been recognized it was not thought necessary to specifically state the fact until the whole sequence had been made out and appropriately defined.

As a series the Des Moines formation is perhaps not so important as any one of the other three members of the Carboniferous system, yet a knowledge of its stratigraphy will always be much more complete for the reason of the great economic value of its mineral contents and of the great extent to which these are being continually sought. At the same time the series is, as compared with the others, much more complicated stratigraphically, its lithological characters change rapidly from place to place and from horizon to horizon, and its faunas and floras are variable. In itself it is a very compact series, sharply set off from the other members both geologically and geographically. Although when Des Moines was first proposed as a geological term the formation was not referred to a specific vertical section nor its exact upper limits defined it was clearly stated and repeated subsequently* that it was sharply contrasted with the rocks of the next higher stage in lithological, stratigraphical and faunal characters, and that the change took place where the limestones began to come in. Soon after,† however, the superior line was located definitely at the base of the first great limestone, the Winterset limestone of Iowa and the Bethany limestone of Missouri. The upper delimiting horizon of the series is therefore the bottom of the limestone, which forms the basal member of the overlying series.

The nominal history of the Missourian series is essentially the same as that of the Des Moines. In using the name Missouri to designate‡ a geological formation it was in the sense of covering all that had been previously called the "upper" Coal Measures. The lower limit was placed§ at the base of the Bethany limestone. In neither Iowa nor Missouri was the full sequence represented and consequently beyond considering it co-extensive with the "upper Coal Measures" little

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*Iowa Geol. Sur., vol. II, p. 119, 1894.

†Missouri Geol. Sur., vol. IV, p. 82, 1894.

‡Mon. Rev. Iowa Weather Service, vol. IV, p. 3, 1893; and Iowa Geol. Sur., vol. I, p. 85, 1893.

§Missouri Geol. Sur., vol. IV, p. 82, 1894.

was said regarding the exact superior limit. Subsequent inquiry showed that a definite line of delimitation was yet to be decided upon; but this was soon proposed by Prosser* who placed it just above the Cottonwood limestone of central Kansas. This author, however, appears to have misinterpreted the scope of the proposed Missouri formation for he makes it a subdivision of the "upper Coal Measures" and of equal rank with two other formations which he names the Wabaunsee and Cottonwood (limestone), whereas both of the latter are minor divisions of the upper part of the former.

The name Missourian was adopted for the reason that the formation is typically developed in the northwestern part of the state of Missouri, and the great Missouri river also winds its way for a distance of more than 400 miles through the beds of this age. The series is made up of strictly marine beds. It is terminated above and below by limestones. The basal member, the Bethany limestone, separates it sharply from the shore deposits of the Des Moines series which lie beneath it. The top of the Cottonwood limestone forms a superior limit that is at once distinctive and easily recognizable in all geological characters.

In suggesting the name Oklahoman as a serial geological term it is intended to apply to all those rocks of Carboniferous age which occur north of the Canadian river in Oklahoma and which lie between the interval of the top of the Missourian series and the base of the Cretaceous. It may be regarded as essentially covering the same succession of strata that has long been vaguely known under the title of "Permian." The name is derived from the territory in which the formation has its best development and in which the most complete sequence is represented. The best sections across the belt appear to be exhibited along the Cimarron, Arkansas and Kansas rivers, and these sections may be considered typical. The beds composing the formation constitute the highest series of the Carboniferous in the Interior basin. Although there has been little detailed study in the region regarding the relations of the series under consideration and the Cretaceous above, it is well known that the latter rests in marked unconformity upon all four series of the Carboniferous and at the north extends over still older formations.

*Journal of Geology, vol. III, p. 800, 1895.

Regarding the lower limit there has been until very recently no satisfactory horizon decided upon. As the so-called Permian in this part of the continent is essentially co-extensive with the Oklahoman series the discussion of the former may be properly considered as applying to the latter. This has already been referred to in connection with the location of the summit of the Missourian. The Oklahoman therefore reached downward to the top of the Cottonwood limestone, which sharply separates it from series beneath.

NOTES ON CAMBRIAN FAUNAS--THE GENUS MICRODISCUS.

By G. F. MATTHEW, St. John, N. B., Canada.

This genus, which by the small number of its pleural joints is almost on a par with Agnostus, exhibits a variation of form according to the age of the beds in which it is found, showing a development of the type comparable to that in Agnostus, but on different lines.

In the Olenellus fauna three types of the genus Microdiscus are found, distinguishable by the form and length of the glabella and the number of rings in the axis of the pygidium. Two of these types show in the Paradoxides zone, but are remarkable for the great development of the occipital spine. This spine is not merely an extension of the crest of the occipital ring, but carries with it the posterior part of the glabella; hence like Agnostus these species have the occipital ring, either quite obscure, or entirely effaced. Two types were long ago recognized in the Paradoxides beds by the late professor C. F. Hartt, who gave to one the name Dawsonia* and to the other Eodiscus.†

We cannot trace any increase of the number of joints in the thorax that may seem relative to the geological age of the form, except that while *speciosus* of the Olenellus fauna has three joints, *punctatus* of the Paradoxides fauna has four. On the other hand, however, *sculptus* and *dawsoni*, both of the lower Paradoxides fauna, have respectively four and two‡ joints.

*Acadian Geology. 2d ed. p. 655, fig. 228.
†U. S. Geological Survey, Bulletin 10, p. 24. pl. ii, figs. 1*a* to *c*.
‡In *M. dawsoni* this is for an individual not fully grown.

It is otherwise with the occipital spine, for in all the species of the Olenellus zone this is only an obtuse protuberance including the last lobe of the glabella and the occipital ring, most pronounced in *M. helena*; but in the Eodiscus section, in the Paradoxides zone, the length of this spine bears a direct relation to the special sub-zone in which the species is found. Thus *precursor* and *suecicus* are found in the Eteminicus (=rugulosus) sub-zone, *pulchellus* in the Abenacus (=Tessini) sub-zone, *punctatus* and *eucentrus* in the Davidis sub-zone.

All the long spined species may be said to belong to the Paradoxides fauna, but the species with blunt occipital rings to the Olenellus fauna: and of the species of the Paradoxides beds, those which bore the longest spines appeared latest.

The following scheme will show how the species of Microdiscus are related to each other:

GENUS MICRODISCUS.

Section, LOBATUS. Long glabella, occipital ring obtusely pointed. 4–6 rings in the pygidium.

Olenellus zone { *M. lobatus* Hall, *M. meeki* Ford. *M. parkeri* Walc., *M. helena* Walc.

Section, SPECIOSUS. Long glabella, occipital ring obtusely pointed. 10–12 rings in the pygidium.

Olenellus zone, *M. speciosus* Ford, *M. bellicinctus* S. & F.

Section, DAWSONIA. Short glabella, occipital ring spined. 6 rings, and lateral costa in the pygidium.

Paradoxides zone, *M. dawsoni* Hartt, *M. sculptus* Hicks.*

Section, EODISCUS. Short glabella. occipital ring pointed or spined.

a,—6–12 rings in the pygidium.

Olenellus zone, *M. schucherti* n. sp., occipital ring pointed.
? *M. connexus* Walc., " " spined.

b,—Pygidium unknown.

Paradoxides zone (P. eteminicus, sub-zone.) } *M. precursor* Matt., occipital ring, with short spine.

Pygidium with 10–12 or more rings, long occipital spine.†

(P. eteminicus, sub-zone.) (P. abenacus, sub-zone.) } *M. suecicus* Linrs., *M. pulchellus* Hartt.

(P. davidis, sub-zone.) *M. punctatus* Salt., *M. eucentrus* Linrs.

Note on the two species of the Olenellus zone.

Through the kindness of Mr. Chas. Schuchert I received several years ago a number of fossils obtained from the Ole-

*Dr. Hicks does not figure or mention an occipital spine as existing in this species. On account of the associated fauna and the resemblance to *M. dawsoni*, I assume that it had one.

†Linnarsson's figure of *M. suecicus* does not represent this spine, but his description implies that this species possessed a spine.

nellus beds near Troy, N. Y. Having lately examined these in connection with a study of the species of this genus, found in the Paradoxides zone, I have had occasion to pen the following note:

Microdiscus lobatus Hall.

Among Mr. Schuchert's fossils were a number of trilobite shields bearing the above name, and among them a good example corresponding to the figure and description of the head-shield of that species, as given by Mr. Walcott. The example, however, is considerably larger than the one described by that author,* and the furrows of the glabella not so distinct as represented in the description.

In the "Fauna of the Olenellus zone" Mr. Walcott says the figure referred to *M. lobatus*, fig. 1*a*, is probably that of a young specimen of *M. speciosus*; but the example of *M. lobatus* received from Mr. Schuchert very nearly corresponds to this figure, and yet is nearly as large as the adult shield of *M. speciosus* represented by figure 3*c*.† I judge, therefore, that Mr. Walcott's first determination of fig. 1*a* as the head shield of *M. lobatus* was correct, though it represents a young individual, while fig.1 is a still smaller head retaining embryonic characters. Whatever may be the fact, fig. 1*a* very fairly represents the appearance of an example of *M. lobatus*, head shield 4 mm. long.

Among the fossils received from Mr. Schuchert were a number of examples of a new species of Microdiscus, which is of considerable interest, as presenting in the Olenellus beds an ancestral type of the section *Eodiscus*, which became so greatly expanded in the later (Paradoxides) fauna. The following are its characters:

Microdiscus schucherti n. sp.‡

Head shield semi-circular, one quarter wider than long, flattened in front, drawn in and upturned at the genal angles; axis projecting behind. Anterior marginal fold enclosing at the front a flattened area, which is indented in front of the glabella. Glabella two-thirds of the length of the shield, cylindro-conical, depressed in front, elevated and projecting backward behind; three pairs of furrows faintly impress the sides. Occipital ring not visible. Cheeks moderately arched, not meet-

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*U. S. Geol. Surv., Bull. 30, p. 156, pl. xvi, fig 1*a*.

†U. S. Geol. Surv., Bull. 30, pl. xvi.

‡Figures of this species will probably appear in the Transactions of the New York Academy of Science.

ing in front of the glabella. Posterior marginal fold wide at the outer end, shield narrower here than opposite the cheeks.

Thorax not known, but the relief of the approximate margins of the two shields indicates a prominent rachis and strongly geniculated pleura, with furrows directed forward.

Pygidium longer in proportion than the head-shield and more decidedly arched. Rachis nearly three quarters of the length of the shield: it has about six joints, the anterior four prominent and each crowned with a tubercle. Side lobes sloping down to a flattened marginal fold, which is strongly geniculated at the front, with an almost vertical outer slope.

Sculpture. Surface of both shields minutely granulate.

Size. Length of pygidium 3 mm.: width 4 mm.: the head shield is somewhat shorter.

Horizon and locality. Limestone of the Olenellus zone at Troy, N. York. Collected by Mr. Chas. Schuchert.

A comparison of the young or larval forms of *M. pulchellus* or *M. punctatus* with the adult of this species is quite instructive and shows how this type has changed from the time of its appearance in the Olenellus zone until its extinction in the P. davidis sub-zone. Especially do we see how the anterior axial furrow originated on a flattened margin, first with a small pit in front of the glabella, as in *M. schucherti*, then passing to a furrow as deep as the dorsal or the marginal furrows, and then in the tumid species, when the whole shield becomes strongly arched, this axial furrow becomes much shallower and tends to disappear.

Comparing with Agnostus, the pit in *M. schucherti* in front of the glabella is parallel to the sharply indented furrow of *A. fissus*, and while in the thick-shelled sections Limbati, Parvifrontes and Lævigati, of Agnostus this furrow is effaced, in the thin-shelled Longifrontes. or at least the majority of them, this furrow being necessary to stiffen the front of the shield, is retained.

ON THE OCCURRENCE OF SILURIAN STRATA IN THE BIG HORN MOUNTAINS, WYOMING, AND IN THE BLACK HILLS, SOUTH DAKOTA.

By C. E. Beecher, New Haven, Conn.

At the request of W. H. Weed of the United States Geological Survey, the writer herewith makes a brief statement regarding two western localities of Silurian, one of which, so far as known, has not been hitherto noticed. Their chief

interest lies in the fact that few identifications of similar horizons have thus far been made in the Rocky mountain region. Unfortunately most of these are more or less uncertain because based upon species having a considerable geological range, and, therefore, not determinative. Apparently nothing short of a thorough study of these western faunas, together with an abundance of material, will permit of exact correlations with geological standards elsewhere.

This was shown conclusively by Walcott in the Canyon City section, Colorado, where the fossil faunas from the Harding sandstone and Fremont limestone have a distinct Trenton facies, although there is a decided commingling of what would be considered in New York state as typical Niagara species.* Therefore the discovery of *Halysites* in the Wasatch range, by Hayden; in the Wind River mountains, by Comstock: in Nevada, by Hague: and in the Téton range by Bradley, does not necessarily imply the presence of Niagara strata at these localities. A knowledge of the complete faunas may show that some are Hudson and others Trenton, while still others may be really Niagara. as they appear at first sight.

The fossils from the first locality to be noticed were collected by Capt. G. E. Bushnell, U. S. A., and presented to the Yale Museum. The specimens were obtained from near Buffalo, Wyoming, on the eastern flanks of the Big Horn mountains, and occur in a hard yellow, siliceous dolomite, in which the organic remains are completely silicified. Corals are the most conspicuous and abundant forms. *Heliolites interstinctus* L. and *Halysites catenulatus* L. being especially numerous. With them are also *Favosites* and cyathophylloid corals of *Zaphrentis* and *Amplexus* types. The only brachiopods are a fragment of a *Rhynchotrema* related to *R. increbescens*, and a single small *Scenidium*-like shell, which may be the young of a large *Orthis*.

Were it not for the Lower Silurian (Ordovician) fauna at Canyon City, and the doubtful presence of *R. increbescens*, these fossils would be unhesitatingly correlated with the Niagara, but in view of what is now known, the possibility must be admitted of their finally proving to be of Trenton or Hudson age, and without larger collections their precise hori-

*Bull. G. S. A., vol. 3, pp. 153-172, 1892.

zon must remain indeterminate between the limits of the Trenton and Niagara.

The other locality to be mentioned is a few miles southeast of Deadwood, South Dakota, and was visited by the writer in 1889. Here a heavy bedded, yellow limestone occurs above the Cambrian and at some distance below the Carboniferous limestone. Fossils are not abundant, the only forms observed being a large annulated orthoceratite and a large gastropod. Specimens of these were sent to Walcott by F. R. Carpenter in 1891, and determined to be *Endoceras annulatum* and *Maclurea logani*, and therefore indicative of Trenton age.* Examples of *Halysites* from this region led the writer to infer the presence of Niagara, and it was so recorded in the fourth edition of Dana's "Manual of Geology," but, as in the previous instance, recent investigations have shown the unreliability of several species generally considered as characteristic of the American Niagara, notwithstanding that in Europe the same forms are well known to have a wide vertical range.

THE AMOUNT OF WATER IN THE EARTH'S CRUST.

W. B. Greenlee, Ithaca, N. Y.

In order to ascertain the amount of mechanically contained water in the earth's crust I recently made the following computation:

I considered it safe to assume that the crust of the earth is filled with water and that the maximum porosity of rocks which can be obtained in the laboratory, though not the greatest possible porosity, is less than that of the crust of the earth for a distance of one mile from the surface.

One mile is taken as an approximate thickness since that seems to be a fair average of the thickess of sedimentary rocks over the surface of the earth.

Assuming then that the earth is saturated with water to the depth of one mile, we have next to determine the relative amounts of its constituent rocks and their respective porosities.

The surface of the earth may be divided into two divisions. first, that covered with sedimentary rocks, and second, that

*Loc. cit., p. 163.

covered with igneous and metamorphic rocks. To ascertain the relative areas the United States and Europe were selected as typical of the land surface. The United States was divided into three regions: (1), that east of the Mississippi river; (2), that between the Mississippi and Colorado; and (3), that between Colorado and the Pacific. The first region was divided as to the relative amounts in each state and the results added. The central region was bulked as sedimentary rocks and the western region was called half sedimentary and half igneous and metamorphic. The results showed that 31.2 per cent. of the surface of the United States is covered with igneous and metamorphic rocks.

In Europe each country was separately divided and the percentage of the respective sums taken. This proved to be 19.8 per cent. An average of these results, by coincidence, is 25.5 per cent. or, roughly speaking, three-fourths of the land surface of the earth is covered with sedimentary rocks, having an average thickness of one mile.

Difficulty was encountered in ascertaining an average porosity. Sections were taken in various parts of this country, notably the 127,000 ft. generalized section of the Rocky mountains, a generalized section through New York, Pennsylvania and Ohio by various authorities and Fairchild's section at Rochester, N. Y. A mean and average rock would appear to be a fine-grained sandstone or limestone.

The most accurate determination of the porosities of rocks has been made by Prof. Bauschinger of Munich. He found the average porosity of upwards of 300 specimens of sandstones and limestones to be 20% of their volumes. Two per cent. may be taken as a low average for igneous and metamorphic rocks.

The most recent and careful computation of the respective areas of sea and land on the earth's surface is that by M. Thoulet in his "Oceanographie." This he gives as 368,000,000 kilg. for the sea and 142,000,000 kilg. for the land, or reduced to square miles, 142,084,860 and 54,826,200 respectively. Three-fourths of the land is 41,119,650 square miles, and one-fourth, 13,706,550 square miles. Taking 20% of the former and 2% of the latter and adding we get 8,498,061 cubic miles of water.

Thoulet estimates the volume of the oceans at 1,347,874,850 cu. kil., which reduced to English measure equals 318,191,728 cu. miles.

The estimated amount of mechanically contained water in a section of a mile over that part of the earth's crust covered by land is thus 2.7% of the water now on the earth's surface, or a layer 88 feet deep over its entire surface.

There is undoubtedly a large amount of water below one mile, but we can only conjecture as to the amount, nor does this estimate include that chemically contained. No estimate was made of the amount of water beneath the bed of the ocean, as we have no way of knowing of what it is composed or how thick the permeable layer is. This too would increase the total.

EDITORIAL COMMENT.

The present condition of the Geological Society rightly gives its friends a gratified confidence in its long life and wide usefulness. It came none too soon and, under the guidance of judicious officials, it has suffered neither the ills of prematurity nor the sequelæ of o'er rapid growth. No rivalries or schisms divide its ranks, and its membership is working compactly and in perfect harmony toward the objects of the association. Our attention, however, is often forcibly directed to the fact the Society's results, as shown in its publications, are almost exclusively geological. This is as it should be, for such an end the organization exists. Here and there among the bulletins of the Society will be found paleontologic papers of character, but these are extremely few and upon looking over the membership list we must infer that they have had therein but few readers. How many of the members have read, for illustration, the papers of Jackson and Jaggar on the morphology of certain echinoderms? and with what propriety anyway, one may ask, do such papers, however excellent, appear in the publications of a geological society? They contain nothing geologic except that the subjects are fossils; their method is not germane to the geologic mode and their conclusions altogether beyond the scope of the geologist. On the other hand, how many of the handful

of paleontologists in the membership keep in touch with the body of the Society's work, devour and digest its important petrographic, stratigraphic, orographic, tectonic and glaciologic papers? Undoubtedly not one. While these paleontologists will of course be welcomed constituents of the Society as long as their fees are paid, we wish to here observe how increasingly peculiar the status of the paleontologist is becoming with reference to his nearest neighbors, the geologist and the zoologist. Paleontology, suggests a recent writer, is a word which has lost its usefulness; let the student of extinct organisms station himself in the ranks of the biologist where he belongs. That this is where he already is no one can deny who will consent to use the term biology with precision. But nevertheless a paleontologist becomes uneasy and bewildered when forced into commerce with men who know not the hammer and chisel, but ply the scalpel and microtome and who pasture only on soft tissues. The methods of the two are as widely unlike as it is possible for them to be, and there are so few in either that are excellent in both lines of work as to raise a fair doubt that these distinct accomplishments are within the reach of ordinary assiduity. There are a few brilliant cases proving exceptions to the statement that when the zoologist ventures among fossil forms he generally makes a mess of it. Certain it is that the first element in the making of a paleontologist is geological, and this element must be most scrupulously nurtured if the best results are to be acquired from the study of either the morphology of extinct organisms or the significance of extinct faunas. Let him borrow as he can from the zoologist, he repays abundantly in broader conceptions of animated nature and in the interpretation of the history and significance of existing life forms. Is the paleontologist, primed with his preliminary geological training, better fitted for his work by the courses in zoological demonstration as usually offered in the German, English and American universities? Little; and for the reason that teachers of zoology seem to interest themselves but little in the outcome of paleontologic investigation, or if they know its results do not recognize them as such. Time and again has the zoologist been compelled to remodel his plans at the behest of the paleontologist and if the former eschews an organism

into which he can not inject his staining fluids and which is insubordinate to his knife, the latter is justified in feeling that his colleague should not attempt to unfold the whole plan of nature from the few remnants of life left upon the earth. With the geologists this man is the lender. In questions of stratigraphy among sedimentary rocks he is the court of last resort. The "stratigraphic geologist" exists upon official lists, but unless he is trained to the niceties of his vocation his conclusions are lame until the paleontologist supplies him with arguments. If the working paleontologists seeking organization for mutual helpfulness and the progress of their interests will hardly acquire these ends by consociation with the zoologists, they are at least more at ease among the geologists; yet the growing importance of their themes, the singular nature of their subjects and their unique methods indicate that they will never get what they most need from organization nor establish their character as a peculiar people until they get by themselves. Perhaps the active body of American paleontologists will see the usefulness and practicality of effecting such an organization and demonstrate that while they may be neither geological fish, nor zoological flesh they are, nevertheless, good red herring.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Ueber die Beziehungen der fossilen Tabulaten zu den Alcyonarien. By F. W. Sardeson. (Neues Jahrbuch für Min., Geol. und Pal. Beil. Bd. x, pp. 249-362; Stuttgart, 1896.)

By those who are interested in Palæozoic corals any serious attempt to advance or increase our knowledge of that large and difficult group must be greeted with pleasure. However, a recent and somewhat extended treatise on "The Relation of the Fossil Tabulates to the Alcyonaria" seems to be a step in the wrong direction. I refer to the paper cited above, which was prepared as a thesis for the doctorial degree in the Albert Ludwig University of Freiberg.

The author, with questionable result, has brought forward and elaborated certain propositions of Mosely (Phil. Trans. Roy. Soc., vol. 166, pt. 1, p. 91, 1876; Challenger Rep. Zoology, vol. II, p. 102 et seq., 1881) relative to the relationship of Palæozoic and recent corals. It was on occasion of his discovery that Heliopora belonged to the Alcyonaria, and in view of the long recognized relationship between that genus and the fossil Heliolites, that Mosely opened this question.

A discussion of the method employed and the scientific results obtained in this paper is the best general criticism that can be made. The Auloporidæ and the Syringoporidæ (including Syringopora and Romingeria) are considered as the fossil ancestors of Tubipora and its allies; Trachypora, Striatopora, Pachypora, Alveolites and Cladopora are ranked with the Gorgonias; Thecia, Michelinia, Favosites, Heliolites, Halysites, etc., are placed under the Alcyonacea, and Fistulipora, Monticulipora, Chætetes and their allies are regarded as representing the Pennatulacea (!). This last, seemingly, for the curious reason that having divided the Alcyonaria into the Tubiporacea, Gorgoniacea, Alcyonacea and the Pennatulacea, and the fossil tabulates into four similar groups, having accounted respectively for the first three divisions of each group, there remained the Pennatulacea on one hand and the monticuliporoids on the other to be associated, simply because they were residues. It will be noticed that Syringopora, Aulopora, Michelinia and Favosites, which are usually considered to be closely related, are here placed each in a different family, while Syringopora and Aulopora on one hand, with Michelinia and Favosites on the other, are even referred to different orders.

The method employed by Mr. Sardeson is by linking genus and genus in a prolonged series. But in so doing each genus is not taken as a whole, as a concept of all the component species. A single species, often, it may be said, the type species, is discussed in more or less detail and its characters taken as representing the genus. The dangers of such a proceeding are apparent. By this method generic and specific characters are not differentiated and phylogeny is liable to be based upon points which have no constant systematic value. Furthermore, another weakness in this system, the same characters or group of characters are not used consecutively for classificatory purposes, but in any portion of the series, *a*, *b*, *c*, the common features which linked *a* to *b* may be entirely lacking in c, while *c* may be ordered with *b* on the strength of characters which are similarly lacking in *a*.

But the most serious arraignment I have to make of the general method employed is that in a paper of over one hundred pages, a paper which is systematic in its purpose if it is anything, the preëminent value of embryologic phases as phylogenetic factors is entirely overlooked or slighted. Indeed, the statement is so generally true that it may be made without modification, that nowhere has the writer used either embryologic stages or the succession of organic types in geologic time, as a proof or as a check upon his work. Not only not performing investigations himself, but not even taking advantage of investigations already made, whether in the field of zoology or palæontology, he pursues a theoretic course independent of facts of supreme importance ready to his hand. The following are criticisms on a few points developed in Mr. Sardeson's paper:

The distinctive character of the Alcyonaria seems to consist in the fact (1) that the skeletal tissue, when calcareous, is not solid, but composed of separate spicules, which, however, are sometimes cemented b

subsequent calcareous deposition, into a more or less solid mass; (2) the symmetry is invariably by eights, there being eight fringed tentacles and eight mesenteries; (3) the polyps do not normally form calcareous thecæ and never, as in other corals, form septa developed between the mesenteries; (4) the colony is usually dimorphic.

In the aberrant type Heliopora the skeleton is not made of small club-shaped spicules like the other Alcyonaria, but is composed of long spicular rods, parallel and in contact, forming a dense stony structure. The apparent septa are the result of the so-called coenenchymal gemmation, are not formed between the mesenteries, of which they are wholly independent in number and position. They are, therefore, not septa but pseudosepta.

In looking for these typical structures in the forms ranked by Mr. Sardeson with the Alcyonaria we find them peculiarly lacking. With scarcely an exception the skeletal tissue of these forms is not spicular but solid. This difficulty is met by Mr. Sardeson by invoking a great principle: "The reduction of an originally compact, calcareous skeleton to a spicular one or its transmutation to a horny one, or eventually to a disappearance of the skeleton altogether," which has been active among "the sponges, coelenterates and many mollusks." It seems, however, that this principle cannot be looked on as of universal application, nor even as a matter of common occurrence, except perhaps in diverted and isolated types. Therefore, until the relationship between the tabulates and the Alcyonaria be proved more satisfactorily than Mr. Sardeson has succeeded in doing, we cannot accept this law as applying to this particular case.

That the fossil tabulates nearly always develop septa of some kind, is met by calling all the structures referred to, pseudosepta, as those of Heliopora. The distinctive character of pseudosepta, however, is that they are independent of the polyp in whose calyce they occur. They, therefore, are small and indefinite in number. They vary in mature individuals of the same colony and in the same individual at different points in its development. Now, in the fossil tabulates the septa are sometimes quite well developed and they are usually constant in number. They are probably not pseudosepta then, but true septa. Indeed, it is interesting to observe the strange recurrence of the cabalistic number twelve in connection with the vertical septal rows; so much so, in fact, as to justify the belief long held, that in most of the fossil tabulates the symmetry of the polyps was by sixes instead of eights.

As to dimorphism, except in monticuliporoids, which good authorities refer to the Bryozoa, it is conspicuously absent.

To discuss a particular case, one to which Mr. Sardeson has given more personal study, perhaps, than to any other and which is the first one treated in his paper, the relationship of Heliopora to Heliolites. Heliopora seems to be more closely related to Heliolites, than are any other of the Palæozoic corals discussed, to what the author regards as their living representatives. The similarity between these two genera has long been recognized, but is, I believe, generally overestimated.

As is well known, colonies of Heliopora are dimorphic, consisting of siphonopores and autopores, the former produced from one another by intermural gemmation, the buds springing from the canals by which they are united. The latter are produced by the fusion of a group of siphonopores through the peculiar process known as "coenenchymal gemmation." The autopores are tabulated at long distances and provided with pseudosepta; the siphonopores are aseptate and more closely tabulate. The pseudosepta range in number in mature cells from 11-16, in the same cells at different stages of growth from 2-16. The skeletal substance is composed of radially disposed, parallel, prismatic rods, which are generally placed each at the junction of four siphonopores and are, therefore, essentially quadrilateral. They are firmly united along their opposed sides by dental sutures, and they are excavated along their angles by the siphonopores (Nicholson, Man. Pal. vol. 1, pp. 332, 333). These spicules in cross section show a simple or compound central axis and a radial structure. They are of about the same diameter as the siphonopores, perhaps a little larger.

In Heliolites also the colony is dimorphic. The autopores are provided with septa, the number of which is almost invariably twelve in each corallite. Usually they are lamellar and often "extend to a considerable distance into the interior of the visceral chamber, sometimes meeting to form a reticulated columella (*H. intrica*), or even showing alternately large and small septa." (Nicholson, p. 337.) They are, therefore, true septa, and the symmetry of the polyp must have been hexameral, not octameral as in the Alcyonaria. The skeleton is not spicular and the walls are thin (in strong contrast to those of Heliopora in every way), but those of the autopores are stronger than those between siphonopores. The siphonopores reproduce usually by fission, seldom by intermural gemmation. The autopores, according to Sardeson, increase by coenenchymal gemmation, very much as in Heliopora, i. e. the several siphonopores become confluent, the incipient autopore gradually increases in size, at the same time assuming thicker bounding walls and developing the regular number and arrangement of the septa. On the other hand, Nicholson describes the process as fundamentally different. The future autopore is first outlined by a thickening of the bounding wall, the included siphonopores still retaining their own proper walls. Then they are "seen to be suddenly arrested in their growth and commonly to be cut off by a common tabula, their place vertically being taken by a single autopore" (Nicholson, p. 337). Nicholson's reputation as an accurate observer requires that Mr. Sardeson's observation should be verified.

In fact it appears that Heliolites resembles Heliopora principally in but two points; in being dimorphic, and in having coenenchymal gemmation. On the other hand, it differs from Heliopora entirely in the skeletal structure of the corallum, in being provided with true septa, in having hexameral instead of octameral symmetry. Dimorphism itself is a diagnostic feature of no great importance; it is found in the fistuliporids, in many Bryozoa (Palæozoic), even in *Favosites*(?) *canadensis*.

The development of siphonopores in the two genera is essentially different, perhaps that of the autopores, though still passing under the name of coenenchymal gemmation. The latter is beyond doubt a singular and striking phenomenon (yet it occurs in the monticuliporids) and should perhaps serve as a preliminary index of more intimate relation. But when this indication is belied by a total absence of structural agreement, in face of a time break from the Devonian to the Cretaceous without any intermediate forms, are we justified in regarding "coenenchymal gemmation" as a criterion of more than class relationship? Certainly Nicholson was corrected in placing Heliopora and Heliolites in different families. Perhaps he would have done better by removing the latter from the Alcyonaria altogether.

Dimorphism and coenenchymal gemmation are usually regarded as indicating Alcyonarian character. Of the tabulates which Mr. Sardeson ranks with the Alcyonaria, the majority, perhaps, possess only one of these peculiarities, and many possess neither. To explain the absence of dimorphism Mr. Sardeson considers that in the perforate-tabulate group, the mural pores stand as the homologs of the siphonopores in Heliolites et. al. That they could not be regarded as the homologs of autopores is evident since in that case we would have a colony without feeding or reproductive zoöids. He regards the monomorphic form as probably the original type in these genera, but believes that this is not found in Favosites and its allies which he considers to have *lost* their dimorphism instead of not yet attained it. In other words Favosites is a Heliolites colony in which the siphonopores have gradually decreased in number until no trace of them is left except in the mural pores with which they are homologous.

If this theory is correct we would expect to find this change indicated in some way in the embryologic condition of the corallum. Now it so happens that Favosites is one of the few genera with whose development we are somewhat familiar, and nothing of the sort is found to occur. Furthermore it is evident that we would have the autopores antedating and giving rise to the siphonopores (since Mr. Sardeson must admit that the connecting pores in the walls of Favosites are of the same nature as those which from time to time become the starting point for new cells), the reverse of what is found in Heliopora and Heliolites. and the siphonopores not producing other siphonopores whether by intermural gemmation as in Heliopora, or by fission as in Heliolites, nor developing autopores by coenenchymal gemmation. We would in fact have to regard each siphonopore as developing directly into an autopore (when it did not subsist as simply a mural opening) all distinction between autopore and siphonopore being lost, and all the individuality of coenenchymal gemmation existing in its name alone.

The paper closes with a theoretical discussion of the form of the corallum in colonies. Mr. Sardeson considers that the shape is conditioned by the direction from which the food supply is derived. If the food supply comes from above, vertically, the central individuals of the hemispherical mass grow fastest because better nourished, and the

corallum assumes a conical, and then an arborescent shape; if from the side, the lateral individuals would secure most nourishment, and the corallum would take on an explanate shape, while if the food supply drifts in radially, in a convergent manner to the colony, its shape would be hemispherical. The latter condition is scarcely conceivable, yet Mr. Sardeson regards the hemispherical form as the original one for the coral stocks of tabulate corals. He appears to be treating these coral stocks as isolated individuals rather than as communities intimately connected by canals into a single organic body. Under the latter conception it would seem that the condition of vertically derived food supply (the most probable one) would produce explanate colonies instead of arborescent ones, since the former would be most favorably situated for receiving all the food possible, while in the latter case the whole colony would gain sustenance from the efforts of a comparatively small number of polyps, and would eventually become extinct through the competitive agencies of natural selection.

If Mr. Sardeson's explanation is the correct one the coral stock should respond very sensitively to this element which conditions its growth, and as a result we would expect to find all the coralla of one locality, that is, of all existing under practically the same conditions, with the same general form, and also changing together from one form system to another according as the conditions changed, since change they probably would. Indeed, this character upon which the author lays much stress in the course of his work as a valuable phylogenetic character, would sink almost out of any significance whatever. G. H. G.

The University Geological Survey of Kansas, Vol. 1. By ERASMUS HAWORTH and assistants. (Pp. 320, plates XXXI; Lawrence, 1896.) In 1895 the Kansas University, in accordance with an act of the legislature, organized a Geological Survey of the state. The first volume, treating of the stratigraphy of the Carboniferous formations, has appeared.

The floor of the Kansas formations, as revealed by the drill, is a mass of Mississippian limestone and flint, outcropping over an area of 30 square miles in the southeast corner of the state. This floor dips to the west while the surface rocks dip to the east. The geologic structure on the whole is simple, though complex in detail. The present report considers only the Carboniferous formation, which consists of alternating beds of limestones and shales, the latter in places grading into sandstone. The limestone outcrops, in the process of weathering, are left as escarpments so that a person travelling from east to west passes from shelf to shelf. This peculiar feature is admirably illustrated in the accompanying map drawn in semi-perspective to show the different formations in their relative positions.

Eight chapters are devoted to detailed descriptions of several geologic sections. The first one is a section from Galena to Wellington by Geo. I. Adams, and extends from the Mississippian formation westward 150 miles. The aggregate thickness of the Coal Measures and Permian along this line is 2,796 feet and the ratio of limestone to the total thickness is about 1 to $5\frac{1}{2}$. In the following chapters other sections are

discussed by Professor Haworth, John Bennett, M. Z. Kirk, John G. Hall, and E. B. Knerr. Near Strong City occur the most pronounced anticlinals and synclinals in all the Coal Measure area, with an angle of 200 feet to the mile with the horizontal.

Haworth devotes chapter IX to a summary of the stratigraphy and correlation of the formations. Two general laws hold for the various formations. They dip and thicken to the west, and the limestones are the most regular and persistent of the various rocks. The total thickness of the rocks is 3,545 feet, 800 feet of lower Coal Measures, 1,950 feet of upper Coal Measures, 795 feet of Permian strata. The basal formation is the Mississippian, rich in deposits of lead and zinc. Next comes the Cherokee shales covering a wide area as shown by well drillings and by comparison with similar formations in Iowa, Missouri, Arkansas, and Texas. Above comes the Oswego and Pawnee limestones followed by the Pleasanton shales, 250 feet thick, throwing out to the north. Above these shales is the Erie limestone rich in fossils with a maximum thickness of 100 feet and covered with 200 feet of Thayer shales. The other strata in order are Iola limestone, Carlyle limestone, Lawrence shales, Oread limestone, Osage City shales, Wabaunser formation of Prosser, Cottonwood Falls limestone ranging 5 to 10 feet thick and a very important building stone.

On account of the frequency of calcareous material with marine fossils, and the great amount of salt water in the shales, Haworth regards them as of submarine origin. The low anticlines and synclines with northwest trend are thought to be due mainly to inequalities in the old ocean floor. There are no faults of large extent noted and no evidence of metamorphism was seen. In the entire Coal Measure system the ratio of limestone to total thickness of the rocks is 1:5, and the largest amount is near the middle of the Coal Measures. The total thickness is not less than 2,600 feet; and the rocks cover on area of 20,000 square miles.

The Kansas Coal Measures are divided into lower and upper on paleontological evidence. The division line is placed at the top of the Pleasanton shales where there is a marked change in life and also a sharp physical change from shales to limestone. The Cottonwood Falls limestone is taken as the base of the Permian as determined by Prosser.

Chapter X discusses Physiography. The streams flow in broad valleys reaching five miles in width and have nearly all reached base level, and are now filling in the lower part of their courses. There are very few broad rolling areas in the Carboniferous area of the state, for the uplands show sharp escarpments, due to the limestone outcrop. In the Permian areas these escarpments are absent. The next four chapters are devoted to preliminary papers on the coal fields, oil and gas, surface gravels, Coal Measure soils, with methods of fertilization.

Twenty counties of the state produce coal of economic importance and four others contain considerable amount of coal. More than 88 per cent. of the coal mined in the state in 1894 came from the Cherokee shale horizon, the thickest vein averaging 40 inches. From a study of the chemical and physical properties of the coals it is found that they

compare favorably with other coals of the Mississippi valley and Ohio. The higher the geological position of the coals in this state the poorer is the grade. The future of the Kansas coal industry is very promising, for the drill has revealed valuable deposits below the surface. An historical account of the development of oil and gas is given. The area of the present territory is 8,500 square miles, located in the southeastern portion of the state. The source is in the Coal Measures and the most productive sands are in the Cherokee shales. The origin is thought to be vegetable and there seems to be little if any relation between location of anticlines with accumulation of oil and gas. These products are more uniformly disseminated in Kansas than in any other territory yet developed in America.

The surface gravels of the Carboniferous series are flint, often fossiliferous. They have a wide distribution and occur in beds of considerable thickness. These gravels have in all probability originated from weathering of the limestones, which contain chert in very considerable amount. They have not been transported any great distance and so were not connected with glacial floods.

The final chapter is by John Bennett, giving a preliminary catalogue of the invertebrate paleontology of Kansas Carboniferous, arranged with reference to biologic aspect and also according to counties. 263 species are enumerated. The richest stratum is the oolitic of Wyandotte county with over 100 species.

By the publication of reports of the high character of the present one Kansas joins the front rank occupied by the various state surveys of the Mississippi valley. This report may be obtained from the survey office at Lawrence by sending 22 cents for postage. G. P. G.

Ice-work, Present and Past. By T. G. BONNEY, Professor of Geology at University College, London. Pages xiv, 295, with numerous maps, sections, and illustrations from photographs. (New York, D. Appleton & Co., 1896. Vol. LXXIV of the International Scientific Series.) The author began his observations of glaciers and study of drift formations forty years ago, and he now reviews the extent of present knowledge of the action of alpine glaciers and of the ice-sheets of Alaska, Greenland, and the Antarctic continent, with application of the principles there discovered to decide upon the claims of opposing theories in explanation of the origin of the European and North American Pleistocene glacial drift. Like the Canadian geologists, Sir William and Dr. George M. Dawson, this English geologist, and, as he assures us, many others in England and Ireland, fail to accept the conclusions of Prof. James Geikie and other Scottish glacialists, and of nearly all who have studied the glacial drift in the United States, that throughout all the drift-bearing areas of both continents vast sheets of land ice and the fresh waters from its melting, without important aid from any marine submergence and floating ice, sufficed to produce all the varied drift deposits. In the British Isles, as in the valley of the St. Lawrence, the local aspects of the drift, and in the latter district the well recognized

Champlain depression of the land and incursion of the sea, from which the country has been since uplifted to a maximum hight exceeding 500 feet, make it difficult to accept the theory which attributes all the drift to land ice. The arguments on both sides are well stated by Prof. Bonney, who evidently inclines toward a compound explanation, nearly like that of Sir William Dawson. The deposits of stratified or modified drift, enclosing marine shells, mostly fragmentary, on Moel Tryfaen, and at Macclesfield, Gloppa, and other localities, extending in northern Wales and northwestern England up 1,100 to 1,400 feet above the sea level, and about 500 feet at Clava in Scotland (AM. GEOLOGIST, vol. XVII, pp. 45-47, Jan., 1896), are regarded as strong evidence of a Late Glacial or Champlain marine submergence to these amounts. Similarly, the Parallel Roads of Glen Roy are thought to be best explained as marine shore lines, although Jamieson, in the latest important paper on that subject, shows how they may be referred to successive stages of a glacial lake held by the waning Scottish ice-sheet,—a much better explanation than was formerly found in fluctuations of local valley glaciers.

The title of this book well indicates its chief purpose, which is a comparison of present and now observable ice action in eroding, transporting, and depositing drift, with the past agencies of striation of the bed-rocks, and accumulation of drumlins, other deposits of till or boulder-clay, marginal moraines, kames, eskers, and all the forms of the glacial and modified drift, together with discussion of its previous subglacial and englacial transportation. A large share of attention is given to the drift formations of North America, and these are illustrated by maps and views. The causes of the Ice age are discussed, but without expressing confidence in any of the current theories; nor is a decision rendered on the vexed question whether there were successive and independent epochs of glaciation during the Pleistocene period. From all the earlier geologic record Prof. Bonney finds evidence of only one other time of widely extended glaciation, this being late in the Carboniferous or early in the Permian period. The Pleistocene glaciation he would refer to a moderate refrigeration of the drift-bearing areas, not necessarily exceeding 12° to 20°, and perhaps even no more than 8° or 6° in New Zealand.

In general, for North America and Europe, the best explanation of the glacial conditions is apparently thought by Prof. Bonney to be the accumulation of large ice-sheets on much elevated central areas whence they are supposed to have flowed outward to terminate on lowlands. The present reviewer, however, would suggest that the preglacial elevation inducing the snowfall and ice accumulation probably included, in variable but everywhere large amount of epeirogenic uplift, all the drift-bearing regions of both continents, the elevation of their peripheral portions being measured approximately by the depth of fjords and the continuation of river valleys, as of the Hudson river southeast of New York city, which descends 2,800 feet beneath the sea level.

Another volume, to cover similar ground as this, is earnestly hoped for by working glacialists, in which Prof. Chamberlin may bring to-

gether, in convenient form for study and reference, his very extensive observations of the glaciers and ice-sheet of Greenland, and his conclusions on their significance for explanation of the methods of origin of the Pleistocene drift. W. U.

Geological Survey of Canada, Report on the Surface Geology of eastern New Brunswick, northwestern Nova Scotia, and a portion of Prince Edward Island. By ROBERT CHALMERS. Pages 149, with five maps and four plates from photographs [the tidal bore on the Petitcodiac river, N. B., and three views of glacial striæ, two of which are ascribed to floating ice]; forming part M of the Annual Report, vol. VII, new series; Ottawa, 1895. Price, 25 cents. The field work on the areas here mapped and described in detail was done in the four years 1890 to 1893; but during many previous years the author has been engaged in similar studies of nearly the entire province of New Brunswick, with parts of the adjacent provinces. In 1885 and 1886 he first published the theory of the glaciation of the eastern part of Canada, south of the St. Lawrence river, which is now found by this further field work to afford the best explanation of all the facts observed. At the period of maximum extension of the North American ice-sheet there was a general radial movement of the icefields enveloping New Brunswick, northward and eastward into the St. Lawrence estuary and gulf, and southeastward into the Bay of Fundy and the Atlantic ocean. The easterly flowing ice reached across Northumberland strait and over Prince Edward Island: but the Magdalen islands, in the south central part of the Gulf of St. Lawrence, were not glaciated, as was ascertained by Richardson nearly twenty years ago, his observations being now fully confirmed.

The ice covering Nova Scotia is thought by Chalmers to have been entirely accumulated by its own snowfall, with no inflow across the Chignecto isthmus; and similarly the ice-sheet enveloping Newfoundland was doubtless chiefly, if not wholly, produced by the local snowfall. Between these ice-sheets of Nova Scotia and Newfoundland, connected respectively with New Brunswick and Labrador by continuous icefields, but receiving from them probably little or no glacial flow or drift, lay an almost enclosed, lower, and warmer driftless area, including the Magdalen islands. The extent of this unglaciated district, although now a part of the Gulf of St. Lawrence so that its boundaries cannot be determined, may well have equaled or exceeded that of the Wisconsin driftless area, with which it seems to be nearly analogous in its topographic and climatic causes. It remains in doubt whether the Magdalen driftless area was ever entirely enclosed by confluence of the ice-sheets which bounded its southern and eastern sides. Since its boundaries and outlet are covered by the sea, it is far less instructive than the driftless area of southwestern Wisconsin and adjoining parts of Minnesota, Iowa, and Illinois, which is separated from the unglaciated country on the south by a wide tract of the glacial drift.

Principally local ice accumulation on the southeastern provinces of Canada, and its radiating eastward outflow, well demonstrated by

Chalmers, seem yet to be wholly consistent with Hitchcock's observations of southeastward glaciation and drift transportation across Maine and the White mountains, doubtless part of a continuous southeast outflow from the Laurentide highlands, belonging to the time of maximum glaciation and indeed probably to the greater part of the Ice age. Furthermore, Chalmers' conclusions for New Brunswick and Nova Scotia are likewise consistent with the reviewer's opinion that a great glacial lake (named the lake St. Lawrence) was formed during the closing stage of the Glacial period by the northeastward recession of the ice-sheet, extending in the St. Lawrence basin from Ottawa to Quebec or beyond, previous to the invasion of that area by the sea when the ice barrier was at last melted through.

During the culmination of the Glacial period, the highest part of the ice-sheet, above the St. Lawrence basin, was probably on the north side of the Adirondack mountains; but when the final melting was far advanced, the summit of the ice on the belt whence it outflowed both westward and eastward in the St. Lawrence valley appears to have migrated until its latest blockade was near Quebec, which is more than 100 miles west of New Brunswick, being on the same meridian as the boundary between Maine and New Hampshire. A large tract of the ice-sheet on northern New England and part of New Brunswick probably remained unmelted until after the ice had vanished along all this valley, so that subsequent glacial outflow from the Green and White mountains doubtless radiated for a short time in all directions, the ice motion being reversed on the north from its early and chief southerly course during the main part of the Glacial period. The southwestward striation and transportation of drift in the St. Lawrence valley westward from Quebec belonged thus to a much later time than the southeastward movement over the mountains of New England; but both preceded the scanty northward dispersal of boulders in the country south of the St. Lawrence river. W. U.

Las Rocas Eruptives de Surveste de la Cuenca de Mexico. By Ezequiel Ordonez. (Bulletin of the Geological Institute of Mexico, no. 2, 46 pp., 1895.) This work is composed of two parts, in the first of which the author reviews in a general way the more salient geographical features of the valley of Mexico and gives a brief description of its geology, showing the genetic relations of the eruptive rocks. The distribution of each different class of rocks is touched upon, all of them belonging to the modern volcanic series; the first which have made their appearance are the trachites, followed by the andesites, labradorites, and last of all the basalts. The author also gives a succinct account of the basaltic volcanoes in the south region of the valley, which volcanoes have in past time sent forth large quantities of lava and cinders. One of these volcanoes, called Xitli, has produced a bed of lava about 12 kilometers in length and six in breadth; judging from the human remains and articles of industry found therein, the eruption must have taken place quite recently, although modern history makes no mention of it.

Further on the author treats of the very interesting chain of volcanoes running nearly due east and west. These volcanic craters lie about 20 kilometres distant from the city of Mexico, on the southeast side. The highest of these volcanoes is the Sta. Catarina, with an altitude of 600 meters above the plain, having a crater 110 meters deep. The mountain of Santiago, as is shown by its dome-shaped form surrounded by a partially destroyed crater, has evidently sent forth a current of viscous lava, which has broken up and destroyed the crater, thus forming a mamelon. In this chain of volcanoes are several intersecting craters, which show that the centre of eruption has moved slowly in an easterly direction, the intensity of these eruptions varying in degree.

In the latter part of the book the author gives a description of the physiography of the mountain of Las Cruces, which lies on the west side of the valley of Mexico, and separates it from the valley of Toluca. This mountain is formed of extensive hills at its base and is crowned by high mountains scarped gently at the top.

A description is given of the very extensive formation of the pumice tufa which represents the first products of that Tertiary volcano. The pumice tufa is extensively used in the building of houses and other structures.

The work concludes with a petrographical description of the lava beds of the volcanoes of Sta. Catarina, considering them as augite-andesite with hiperstbene very similar to those of the volcano Popocatepetl. Rocks from Sierra de las Cruces are trachites and trachi-andesites with pyroxene and hornblende.

In Mexico the trachite is called *Chiluca*, and is considered the best material for construction.

Professor Ordoñez hopes in subsequent articles to continue the petrographical description of all the rocks in the valley of Mexico and to describe in general the geology of this interesting region of Mexico.

On Certain Granophyres, Modified by the Incorporation of Gabbro-Fragments, in Strath (Skye). By ALFRED HARKER. (Quart. Jour. Geol. Soc., no. 206, vol. 52, pt. 2, pp. 320-330, pls. 13 and 14, May 1, 1896.) In mapping, for the Geological Survey of Great Britain, the district of Strath in the Isle of Skye, Mr. Harker has studied some granophyres which contain numerous inclusions of gabbro, and sometimes of basalt. At times the granophyre has taken up foreign material amounting to one-fourth of its bulk. The gabbro fragments are thought to have come from a deep source, and they have in part been dissolved in the acid magma. For this reason the granophyre is of a higher specific gravity and contains more of the ferro-magnesian minerals and more lime-soda feldspar than do the surrounding and similar granophyres. Fragments of augite, which has the peculiar basal striation of the augite of the gabbro, are quite common, and some slides show both foreign augite and augite native to the granophyre. One section is figured which contains a large plate of foreign augite showing distinct ophitic relations to feldspar crystals.

This incorporation and absorption of basic material by an acid magma is not common and is of special interest. The present instance proves conclusively that such a phenomenon does occur. The importance of this phenomenon was mentioned by the author and was further brought out in the discussion which followed the reading of the paper. U. S. G.

The Rubies of Burma and Associated Minerals. By J. W. JUDD. In the Philosophical Transactions Prof. Judd, with C. B. Brown, Esq., gives a detailed account of some minerals collected by the latter when carrying out, under orders from the Secretary of State for India, an investigation into the long known ruby mines of Burma. Details are given, with maps, of the physical geography and geology of the region and the rude processes employed by the natives in mining the gems. They are for the most part washed out of alluvial material filling hollow basins and clefts in a limestone rock, but their original situation, as proved by Mr. Brown, is in the rock itself. This is a hard, crystalline limestone interbedded with gneiss, and by breaking some of it to fragments Mr. Brown obtained in ten days 14 rubies from one and a half cubic feet. These were of course injured much by the jarring necessary to break up the stone, but they showed that by better methods the gems could be obtained in larger quantity.

Prof. Judd says: "The limestone which the rock in Burma most closely resembles is undoubtedly that of Orange Co., N. York and Sussex Co., N. Jersey, which is associated with the remarkable deposits of zinc ore at Franklin Furnace." "The general conclusion to which we have been led concerning the origin of the rubies of Burma is as follows: Pyroxene gneisses abound with an unstable basic feldspar, which is easily converted by minute quantities of hydrochloric acid under pressure into a scapolite, this in turn breaking up into various hydrated aluminum silicates and calcite." While the limestones are being formed from basic feldspars the aluminum silicates, taking up water, may be attacked by sulphuric, hydrochloric, boric or hydrofluoric acid at moderate temperature and decomposed, the aluminum oxide, in some cases anhydrous, being formed, which may assume the crystalline form. The presence of carbonic acid in the liquid state in some of the cavities indicates formation under great pressure. E. W. C.

Sobre la edad de Algunas formaciones Carboniferas de la Republica Argentina. By GUIL. BODENBENDER. (Revista del Museo de la Plata, vol. vii, 1-20, 1895.) Accompanying an exposition of the Carboniferous formation in the Argentine is an important tabulation of the Paleozoic series of that country with its fossils. Above unfossiliferous beds of the Sierra de los Llanos and the Sierra de Cordoba, referred to the lower Cambrian are sandstones of the Olenus zone in the provinces of Jujuy and Salta, containing *Agnostus*, *Olenus*, *Arionellus*, *Orthis*, *Lingula*, and *Obolus*. To the Trenton horizon are referred the limestones and dolomites of the Antecordilleras of San Juan and the Sierra de Farnatina, with *Monticulipora*, *Lituites*, *Murchisonia*, *Maclurea*, *Orthis calligramma*, *Orthisina adscendens*, *Leptaena sericea*, etc. The Silurian

sandstones of San Juan have produced no fossils. The horizon of the Upper Helderberg and Hamilton groups in the same region is indicated by the ubiquitous *Leptocoelia flabellites* and species of the genera *Rhynchonella*. *Meristella*, *Spirifer*, *Strophomena*, *Chonetes*, etc. (These fossils have not as yet been studied with precision so that their exact value is still undetermined.) Upper Devonian sandstones with plant remains overlie these. The Carboniferous sandstones and conglomerates with productive coal beds and numerous plant remains occur in the same districts. Overlying are beds, also coal-bearing, with *Walchia*, *Noeggerathiopsis*, and other plants representing the Permian.

J. M. C.

A Mineralogical Lexicon of Franklin, Hampshire, and Hampden counties, Massachusetts. By B. K. EMERSON. (Bull. No. 126, U. S. Geol. Sur., pp. 180, pl. 1, 1895.) Nothing quite so elaborate and comprehensive has heretofore appeared in the United States in the form of a mineralogical catalogue pertaining to a relatively small area. The region is a historic collecting ground; Profs. Amos Eaton, Chester Dewey and Ebenezer Emmons early entered it. The more precise investigations of president Hitchcock have given it geological importance, while Prof. C. U. Shepard's keen-eyed search for its minerals during more than a half-century has made its localities known to all mineralogists. Prof. Emerson states that his catalogue was intended to accompany his geological monograph of the same district, but is allowed to appear in separate form on account of its large size. The general plan of the catalogue is an alphabetical arrangement of recognized and well established mineral species, under each caption being references to all names under which the species has been cited from localities within the district. Mineralogists will appreciate the complete literature of these species not less than the determination of the exact values of many mineral names applied, especially by Shepard, to forms from this region.

J. M. C.

Traces of the Ordovician System on the Atlantic Coast. By G. F. MATTHEW, D. S. (Transactions of the Royal Society of Canada.) In this tract Mr. Matthew, after mentioning a belt of Ordovician rocks extending from the bay of Chaleur across New Brunswick into the state of Maine, south of the belt of Silurian rocks already known, and another near St. John, gives an account of a third belt of Ordovician strata lately identified by its fossils on the island of Cape Breton and in Conception bay, Newfoundland. The material is scanty and not very well preserved, but in Mr. Matthew's opinion clearly indicates the presence of this fauna farther to the eastward than it has hitherto been recognized in America. It consists of a few lingulids, a trimerellid, an obolid and an orchid, a Hyolithes and a trilobite. Good figures accompany the paper.

E. W. C.

A Summary of Progress in Mineralogy in 1895. By WM. H. HOBBS. (From monthly notes in the American Naturalist. Madison, Wis., 1896. Price 50 cents.) Dr. Hobbs has had reprinted and collected in convenient form his useful notes on mineralogy from the American Naturalist

in 1895. An index of subjects and also one of authors accompanies the pamphlet. In addition to notices of newly described minerals and important contributions to mineralogy, descriptions of new and improved instruments are also given. U. S. G.

Fossil Fishes of the Moray Firth Area. By Prof. R. H. TRAQUAIR. In the above tract, which is reprinted from a larger work, on the Vertebrata of the Moray basin, by Messrs. Harvie, Brown & Buckley, Prof. Traquair has summed up to date our knowledge of the fossil fishes, chiefly Devonian, of Scotland and the reptilian fauna of the Elgin sandstones, with a few Mammalia of quite recent age.

The oldest fish remains were found in the Orcadian lower old Red beds of Cromarty, etc., and occur in limestone nodules. The following list of species is given by the author:

ELASMOBRANCHII.
Acanthodei.

Diplacanthus striatus Ag. — Mesacanthus pusillus Ag.
" teuistriatus Trg. — Cheiracanthus murchisoni Ag.
Rhadinacanthus longispinus Ag. — " latus Eg.

OSTRACODERMI.
Antiarcha.

Pterichthys milleri Ag. — Pterichthys oblongus Ag.
" productus Ag.

DIPNOI.
Sirenoidei.

Dipterus valenciennesi S. & M.

TELEOSTOMI.
Crossopterygii.

Glyptolepis leptopterus Ag. — Osteolepis macrolepidota.
Gyroptychius microlepidotus Ag. — Diplopteris agassizi Traill.

Placodermata.

Coccosteus decipiens Ag. — Homosteus milleri Trq.

Acipenseroidei.

Cheirolepis trailli Ag.

"Nearly all these fishes reappear in the flags of Caithness and Orkney."

The three areas therefore "form one great paleontological series—the Orcadian." Sir A. Geikie has advanced the opinion that they were deposited in a large lake of Lower Devonian age occupying the middle of Scotland.

"Of this assemblage of species *not one* occurs in the Lower Old Red Sandstone of Forfarshire or of any part of Great Britain south of the Grampians."

The indications are therefore of two distinct hydrographical areas for these two faunas.

Unconformably on these Lower Devonian strata lie the Upper Old Red beds of Elgin or Nairn. The stratigraphical relations of these two areas have not yet been satisfactorily ascertained, but their faunal distinctness was proven some years ago by Dr. Traquair.

The fauna of the Nairn sandstones is small, consisting of four species only:

OSTRACODERMI.

Antiarcha.

Asterolepis maxima Ag.

TELEOSTOMI.

Crossopterygii.

Holoptychius decoratus Eich. Polyplocodus leptognathus, sp.n.

Placodermata.

Coccosteus magnus, sp. n.

This fauna, says Prof. Traquair, resembles that of the Russian Devonian beds in Livonia.

The Upper Old Red beds of Elgin have yielded the following species:

ELASMOBRANCHII.

Selachii.

Psammosteus taylori Trq. Cosmacanthus malcolmsoni Ag.

OSTRACODERMI.

Antiarcha.

Bothriolepis major Ag. Phyllolepis concentrica Ag.
" cristata, sp. n. Conchodus ostreiformis McCoy.

TELEOSTOMI.

Crossopterygii.

Holoptychius nobilissimus Ag. Polyplocodus sp ?
" giganteus Ag. Glyptopomus minor Ag.

Dr. Traquair very justly remarks that the above fauna shows manifest indication of being later than that from Nairn.

The overlying sandstones, which many years ago yielded the well known *Telerpeton elginense*, which was then and therefore supposed to be of Devonian age, are now assigned to the Trias in spite of their conformity and the absence of clear evidence of a time-gap between them. These beds have now yielded thirteen traces of Reptilia, but no Bratrachians. Besides the *Telerpeton* alluded to above, the most remarkable of these is the extraordinary *Elginia mirabilis*. "Nothing of this creature is known as yet but the skull, and a most bizarre-looking skull it is, reminding us, as Mr. Newton observes, of the head of the American 'horned' toad on a large scale." The paper is illustrated with nine excellent plates of the fossils described. E. W. C.

RECENT PUBLICATIONS.

I. Government and State Reports.

Geol. Sur. of Penna., Summary Final Rept., vol. 3, pt. 1, pp. 1628-2152, pls. 205-395, 1895. The Carboniferous formation, J. P. Lesley, F. V. d'Invilliers and A. D. W. Smith.

Ibid., vol. 3, pt. 2, pp. 2153-2638, pls. 396-611, 1895. The Bituminous coal fields, E. V. d'Invilliers; Report on the New Red of Bucks and Montgomery counties, B. S. Lyman.

Ibid., General index, W. A. Ingham. 98 and xxx pp., 1895.

Ibid., Atlas to F3.

Bull. Illinois State Mus., Nat. Hist., No. 9, 66 pp., 5 pls., Apr. 20, 1896. New species of crinoids from Illinois and other states, S. A. Miller and W. F. E. Gurley.

Calif. State Mining Bureau, Bull. 8, April 1896. Table showing by counties the mineral productions of California for the year 1895, C. G. Yale.

U. S. Nat. Museum, vol. 18, pp. 281-292, 1895, (No. 1066). Notes on asbestos and asbestiform minerals, G. P. Merrill.

Iowa Geol. Survey, vol. 5, Ann. Rept. for 1895, 452 pp., 14 pls., 7 maps, 1896. Geology of Jones county, Samuel Calvin; Geology of Washington county, H. F. Bain; Geology of Boone county, S. W. Beyer; Geology of Woodbury county, H. F. Bain; Geology of Warren county, J. L. Tilton; Geology of Appanoosa county, H. F. Bain.

Dept. of Geol. and Nat. Resources of Indiana, 20th Ann. Rept. (1895), pp. vi+520, 16 pls., 4 maps, 1896. A preliminary report on the clays and clay industries of the coal-bearing counties of Indiana, W. S. Blatchley; The Carboniferous sandstones of western Indiana, T. C. Hopkins; The whetstone and grindstone rocks of Indiana, E. M. Kindle.

II. Proceedings of Scientific Societies.

Bull. Geol. Soc. Amer., vol. 7, pp. 399-422, pl. 18, Mch. 28, 1896. Cuspate forelands, F. P. Gulliver.

Same. pp. 423-458, pls. 19-21, Apr. 14, 1896. Glacial Genesee lakes, H. L. Fairchild.

Same, pp. 459-558, pls. 22-24, Apr. 21, 1896. Proceedings of the eighth annual meeting, H. L. Fairchild; Memoir of J. D. Dana, Joseph Le Conte: Memoir of H. B. Nason, T. C. Chamberlin; Memoir of Albert E. Foote, G. F. Kunz; Memoir of Antonio del Castillo, Ezequiel Ordoñez; Illustrations of the dynamic metamorphism of anorthosytes and related rocks in the Adirondacks, J. F. Kemp; The share of volcanic dust and pumice in marine deposits, N. S. Shaler; A needed term in petrography, L. V. Pirsson: Examples of stream-robbing in the Catskill mountains, N. H. Darton; Notes on glaciers, H. F. Reid; Paleozoic terranes in the Connecticut valley, C. H. Hitchcock; Notes on relations of lower members of the Coastal Plain series in South Carolina, N. H. Darton; Some stages of Appalachian erosion, Arthur Keith; The Cerrillos coal field of New Mexico, J. J. Stevenson.

Journ. Cincinnati Soc. Nat. Hist., vol. 18, Nos. 3-4, 1896. Manual of the paleontology of the Cincinnati group, part VII, J. F. James; An account of the middle Silurian rocks of Ohio and Indiana, A. F. Foerste.

Proc. Acad. Nat. Sci. Phila., 1895, pt. 1. Pleurotomaria crotaloides Morton, in the New Jersey Cretaceous, H. A. Pilsbry; Two supposed new trap dykes in Chester Co., Pa., Persifor Frazer; The crystallization of molybdenite, A. P. Brown.

III. Papers in Scientific Journals.

Jour. of Geol., Apr.-May. The magmatic alteration of hornblende and biotite, H. S. Washington: On the origin of the Chouteau fauna, H. S. Williams; North American graptolites, R. R. Gurley; Deformation of rocks, C. R. Van Hise.

Ottawa Nat., May. Note on Cardinia subangulata Dawson, and Arca punctifer Dawson, H. M. Ami.

Science, May 15. Current notes on physiography, W. M. Davis; The perogatives of a state geologist, Erasmus Haworth.

Science, May 22. The development of exogenous structure in the Paleozoic lycopods--a summary of the researches of Williamson and Renault, David White; The embankments of the river Po, F. D. Adams: The mammoth bed at Morea, Pa., E. H. Williams, Jr.

Science, May 29. The ape-man from the Tertiary of Java, O. C. Marsh; Two erosion epochs--another suggestion, W J McGee; Current notes on physiography, W. M. Davis.

School of Mines Quarterly, vol. 17, no. 3, Apr., 1896. Lecture Notes on rocks, J. F. Kemp.

Am. Jour. Sci., June. The extinct Felidæ of North America, G. I. Adams; The age of the igneous rocks of the Yellowstone National park, Arnold Hague: On the occurrence of pollucite, mangano-columbite and microlite at Rumford, Me., H. W. Foote; A device for simplifying the drawing of crystal forms, A. J. Moses; On the Pithecanthrophus erectus from the Tertiary of Java, O. C. Marsh.

Appletons' Pop. Sci. Mon., June. How the Great lakes were built, J. W. Spencer; The subterranean river Midroï, Paul Raymond.

IV. Excerpts and Individual Publications.

Geological Notes, Long island and Nantucket, Arthur Hollick. Trans. N. Y. Acad. Sci., pp. 3-10, Oct. 28, 1895.

An account of the summer's work in geology on lake Champlain, Gilbert van Ingen and T. G. White. Ibid., pp. 19-23, Oct. 28, 1895.

The faunas of the upper Ordovician strata at Trenton Falls, Oneida Co., N. Y., T. G. White. Ibid., vol. 15, pp. 71-96, pls. 2-5, Apr. 3, 1896.

Traces of the Ordovician system on the Atlantic coast, G. F. Matthew. Trans. Roy. Soc. Canada, ser. 2, vol. 1, sec. 4, pp. 253-271, pls. 1-2, 1895.

Organic remains of the Little River group, No. IV, G. F. Matthew. Ibid., pp. 273-279.

Geology in the colleges and universities of the United States, T. C. Hopkins. U. S. Bureau of Education, Rept. Comm. of Educ., pp. 819-872, 1896.

Report on an exploration of the Finlay and Omenica rivers, R. G. McConnell. Geol. Sur. Canada, Ann. Rept., vol. 7, pt. C, 40 pp., 2 pls., 1 map, 1896.

Report on the country in the vicinity of Red lake and part of the basin of Berens river, Keewatin, D. B. Dowling. Ibid., pt. F, 54 pp., 1 map.

Report of the section of chemistry and mineralogy, G. C. Hoffmann. Ibid., pt. R, 68 pp.

On the occurrence of cirripedes in the Cambrian rocks of North America, G. F. Matthew. Trans. N. Y. Acad. Sci., vol. 15, pp. 137-140, 1896.

Die krystallisirten Mineralien aus dem "Galena Limestone" des südlichen Wisconsin und des nördlichen Illinois, W. H. Hobbs. Zeitsch. f. Krystal., Bd. 25, pp. 257-275, pls. 3-5, 1895.

A summary of progress in mineralogy in 1895, W. H. Hobbs. From monthly notes in the Am. Naturalist.

Lecture notes on crystallography, H. B. Patton. 34 pp., published by the author, Golden, Colo., 1896.

Sur un cristal de labrador du gabbro de Minnesota, N. H. Winchell. Bull. Soc. Francaise d. Miner., t. 10, pp. 90-92, 1896.

V. Proceedings of Scientific Laboratories, etc.

Bull. Lab. of Nat. Hist., State Univ. of Iowa, vol. 3, pt. 4, Feb.,1896. Notes on the Cretaceous flora of western Iowa, Paul Bartsch. The Le Claire limestone, Samuel Calvin.

Bull. Dept. of Geol. Univ. of Calif., vol. 1, no. 14, pp. 371-428, May, 1896. The Great valley of California—A criticism of the theory of isostasy, F. L. Ransome.

CORRESPONDENCE.

JAMES HALL AND THE NEW YORK STATE SURVEY. In response to your request I send herewith a copy of the engrossed resolutions passed by our Assembly and prompted by the publications of monstrous statements concerning Prof. Hall in the *Journal des Debats* and other Parisian and provincial papers in France and various newspapers throughout Germany and Austria. The Paris journal mentioned is the original offender. Whether it ever printed the official denial of the chancellor of our university, which I took pains to send, I have never learned. Some of the provincial papers did so. You are probably aware of the action taken by the Geological Society of France and the Soc. du Nord. The justification of Prof. Hall and his work was still further emphasized by our legislature in the passage of a law giving him life tenure of his position and entire independence in the management of his affairs.

J. M. CLARKE.

STATE OF NEW YORK.

IN ASSEMBLY.

MARCH 9th, 1896.

On motion of Mr. Finn:

WHEREAS, during the session of the Legislature of 1895 a joint committee was appointed for the purpose of investigating the various departments of the state government, and through a sub-committee investigated the department of geology and paleontology, which for upwards of half a century has been under the charge of Dr. James Hall; and,

WHEREAS, during the time when said sub-committee was engaged in the taking of evidence certain criticisms as to the conduct of said department were indulged in by certain newspapers, which criticisms have been copied by many foreign journals with astonishing exaggerations to the effect that the scientific world was startled by the fact that

our distinguished citizen, Dr. James Hall, was incarcerated in prison as a result of this investigation; and,

WHEREAS, said articles, by their wide circulation among American and foreign journals, do an irreparable injury and wrong to a distinguished state officer, who, since his appointment to his present official position by Governor Marcy in the year 1837, has served his State continuously and with distinguished credit and whose scientific attainments and accomplishments have given him a world-wide fame, therefore, be it

Resolved, That the Legislature of the State of New York desires to place upon its records this denial of the gross and false charges against the official integrity of Dr. James Hall, and to officially announce that they are unjust, untrue and not warranted by any evidence produced at said hearing, and to express its confidence in his integrity, and appreciation of his distinguished services and scholarly attainments, which, during a long life, have reflected such credit upon our State.

Resolved, That a copy of these resolutions be transmitted by the Clerk of this House to Dr. James Hall.

By order of the Assembly.

[Signed,] HAMILTON FISH, Speaker,
A. E. BAXTER, Clerk.

State of New York.
SEAL.
Clerk of Assembly.

NOTES ON THE GEOLOGY OF SOUTHWESTERN NEW MEXICO.—Of the vast area comprised within the "Rocky mountain region of the west" no part is, perhaps, so little known, geologically, as is its southern portion, circumscribed within the area occupied by southwestern New Mexico. Although one or two hasty reconnoissances of portions of this region have been made at different times (but which were, under the circumstances, necessarily brief and more or less imperfect) by divisions of the United States Geological Survey, yet little has been added to our knowledge of it.

For nearly three years the writer conducted systematic researches and investigations in the geology and archeology of southwestern New Mexico, and when requisite extended these researches into old Mexico and Colorado. This area comprises a portion of the extreme southern part of the great "Plateau region" of the west, and it is safe to say that no other portion possesses features of greater geological interest.

The general topographical features of the region are represented by several rugged and extensive mountain ranges, isolated groups and solitary peaks mainly of recent volcanic origin, which usually spring abruptly out of the vast level plains; also wide stretches of sandy desert and narrow fertile valleys. The mountains of this region abound in vastly rich resources of mineral wealth.

What strikes the geologist most forcibly in this region is, perhaps, the *great variety* and *recentness* of nearly all the eruptive rocks, as well as

the large areas of conglomerate or "wash," especially along the Gila, Sapillo and Mimbres rivers. This last formation, which varies considerably lithologically, often attains a thickness of over one thousand feet, and has a prevailing yellowish-buff color. In many places the basalt has forced its way through and overflowed this late formation: while at other localities large areas have been uplifted, tilted and broken by eruptions of basalt.

The next division of greatest interest, although of relatively small extent, is the strata representing the Lower Carboniferous and Cretaceous* ages, all of which are much tilted and broken up by eruptive agencies. The Cretaceous is mainly composed of rather coarse, brownish-buff to gray (sometimes red, locally) sandstone and quartzites, interstratified with a few narrow bands made up almost exclusively of beautifully preserved fossil remains, mainly Gasteropoda and Lamellibranchiata and alternate layers and heavy strata of greenish-black arenaceous shales, in places carrying an interesting flora.

What is of peculiar interest is that almost everywhere, as yet observed, the Cretaceous strata rest immediately upon the granite below, instead of being superimposed upon the older stratified rocks. Only in one or two local areas have I observed the Cretaceous to rest upon the Carboniferous, and here, as might be expected, unconformably.

The Carboniferous is composed of heavily bedded bluish-black limestone, often containing a great amount of chert and yellowish-buff calcareous, and black carbonaceous shales and quartzite. The strata above the quartzite (except the beach shale, which carries a unique but rather rich flora) contain extremely interesting and rich faunas. The fossils are often weathered out (from the calcareous shales) in great numbers and perfect condition.

The fourth division, although first as to magnitude of area occupied, is the Drift formation, which is of much interest and constitutes the great desert plains of this region that stretch onward far into old Mexico.

In the Drift at Deming two apparently entire and well preserved skeletons of mastodons have been exhumed in digging wells, one being discovered approximately twenty feet and the other forty feet below the surface. Only a portion of each skeleton was removed.

A large amount of data in the form of notes, maps, sections, ores, minerals, fossils, etc., have been collected, as well as a large scale geological map of the region constructed.† A detailed account of the result of the field work, etc., accomplished will be published in the near future.

CLEMENT L. WEBSTER.

*I have here *provisionally* considered all the strata above the Carboniferous (not including the conglomerate) as of Cretaceous age, and all below the Cretaceous as Carboniferous. The question as to the exact age of the quartzite (usually considered as Silurian) occupying the lowest horizon in the stratified series here, will be discussed in my future publications on the geology of this region.

†I would here acknowledge my indebtedness to Prof. J. H. Huntington (who has spent many years in southwestern New Mexico), assistant geologist on the State geological survey of New Hampshire, for valuable assistance rendered in my geological labors in this region.

PERSONAL AND SCIENTIFIC NEWS.

Dr. G. P. Grimsley, of Washburn College, will spend the summer in geological work for the University Geological Survey of Kansas.

Mr. H. Foster Bain, assistant state geologist of Iowa, has been appointed to a fellowship in geology at the University of Chicago, where he expects to spend the next year in study.

Prof. J. F. Kemp, of the Columbia School of Mines, started on May 28 with a class of students for Butte, Mont., where the regular summer school of mining and geology will this year be held. He will return via the Yellowstone park and the Black hills.

T. C. Hopkins, assistant professor of geology, State College, Pa., will work on the Geological Survey of Indiana this summer on the investigation of the famous oölitic limestone of that state in company with Mr. Siebenthal. His report on the sandstones of the state has just been published.

Sir Archibald Geikie's Lectures (George Huntington Williams memorial lectureship) before the Johns Hopkins University, which were expected the coming fall, have been postponed until next spring. The lectures will be on the principles of geology, and will begin on Wednesday, April 21, 1897.

A geological excursion will be offered members of the Geological Society of America and the American Association through the Adirondacks, the week before the meeting in August. Prof. J. F. Kemp will have the party in charge in the eastern mountains, Prof. C. H. Smyth, Jr., in the western. Both these geologists expect to continue their field work during the coming vacation.

Dr. Persifor Frazer, one of our editors, appears in Vol. IV of the National Cyclopedia of American Biography with a portrait and a well written biographical sketch, giving quite a full account of his ancestry as well as an account of his work in geology and his other writings. This cyclopedia (James T. White & Co., N. Y.) is very comprehensive and is being made to answer as a national portrait gallery as well as a biographical encyclopedia.

Prof. Ralph S. Tarr, of Cornell University, will accompany Lieut. Peary on his next Greenland expedition. He will take with him a party of five, and besides the trip with several

stops he expects to spend five or six weeks in camp, probably at the south end of Melville bay. The party will consist of one paleontologist, a student of stratigraphic geology, a photographer, a civil engineer, and one other. They intend not only to study the glacial movements, etc., but also the general geology. Arrangements will also be made to collect plants and animals.

ALASKAN GOLD FIELDS. MR. J. EDWARD SPURR has been sent to Alaska by the U. S. Geological Survey to investigate the gold field, especially those of Forty Mile creek. He is accompanied by Messrs. Goodrich and Schrader. The party will cross Chilkoot pass, at the head of Lynn canal, to the waters which flow into the Yukon and will descend by canoe to Forty Mile creek. They expect to spend a year and a half in Alaska, passing the winter in one of the mining camps, and next summer they will descend the Yukon to its mouth and thence back to the United States.

BRYN MAWR COLLEGE. Dr. E. D. Cope lectured May 14th to the students of geology on the argument for organic evolution derived from the paleontological record. The work of the year closes with two excursions: an excursion into New Jersey where the gravels of the Pensauken and Jamesburg, the Raritan clays and clay marls of the Cretaceous series, and the Fish House clays were examined and fossils collected. This excursion was in charge of Dr. Wm. B. Clark. A second excursion is to be taken to Neversink and Penn mountains. This trip will afford opportunities to study Pre-Cambrian, Cambrian, Silurian and Triassic formations.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. The 49th meeting of the A. A. A. S. will be held in Buffalo, N. Y., Aug. 22d to 29th. The Geological Society meets Saturday evening, Aug. 22d, for business purposes, and the papers will be presented before Section E of the A. A. A. S. the following week. During the week preceding the meeting the following excursions will be taken under the auspices of the Geological Society, but intended equally for the members and friends of the A. A. A. S.: 1. Stratigraphy and paleontology, conducted by Prof. C. S. Prosser. 2. Petrography, conducted by Profs. J. F. Kemp and C. H. Smyth, Jr. 3. Economic geology, conducted by Dr. F. J. H. Merrill. 4. Pleistocene geology, conducted by Messrs. G. K. Gilbert, Frank Leverett and H. L. Fairchild. Further information concerning these excursions can be obtained from Prof. H. L. Fairchild, Rochester, N. Y.

CRATER LAKE SPECIAL MAP. An edition of this map with topographic data has recently been issued by the U. S. Geological Survey, accompanied by a description written by Mr.

J. S. Diller. This Oregon lake, occupying a roughly circular pit nearly six miles in average diameter, on the summit of the Cascade range about midway between mount Shasta and mount Hood, is of intense interest and beauty. The lake is 6,239 feet above sea level and is reputed to be the deepest fresh water lake in America, having the remarkable depth of 2,000 feet. It is surrounded by steep and precipitous cliffs, which rise in places over 2,000 feet above the lake, and are composed of sheets of lava and fragmental volcanic material dipping away from the lake. It is thought that the pit, in which the lake is situated, was formed by the sinking of the main mass of a huge volcanic mountain which once rose several thousand feet above the place now occupied by the lake.

ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA. May 19, 1896. Mr. Henry A. Pilsbry spoke of the geology of the deposits containing fossil Unionidæ at Fish Neouse, N. J. The mussels, some twelve species of *Unio* and *Anodonta*, occur in a thick black clay stratum used for brick and tile making. Below this is a stratum of red clay, gravel and "iron-stone" (bog iron) about two feet thick, which rests on a bed of sand of unknown depth. This sand shows the stratification and oblique lamination characteristic of arenaceous deposits in running water. The speaker considered that the hypothesis of our ancient "ox-bow" of the Delaware river explained the phenomena presented; the underlying sand having been deposited in the bed of the river; the channel was then abandoned for a new one, leaving a lagoon or "slough" in which the layer of yellow material was deposited at subsequent times of freshet and after the up-stream end of the lagoon was entirely filled up, the black clay was formed in idle water, largely by the decay of organic matter, molluscan and other life flourishing in lagoons of this nature, Mr. Pilsbry held that the black clay and underlying sand were a deposit wholly different in genesis and earlier in time than the gravel which overlies the clay bed, this last gravel being referred by professor Salisbury to the Pensauken formation. Besides the mussels, fossil wood occurs in the black clay, as well as remains of the Pleistocene horse, *Equus major* Leidy. The latter, as well as the Unionidæ (some of which are recent species) prove the deposit to be of post-Pliocene age, instead of Cretaceous as claimed by Dr. Lea, Prof. Whitfield and some others.

The character and age of the deposits were farther considered by Prof. Heilprin and Mr. Woolman.

May 26, 1896. Mr. Edw. Goldsmith reported that a specimen of supposed geyserite from Hawaii had been found by him to be an amorphous, soluble sulphate of lime. The sub-

stance was formed on the edge of the Kilauea crater, associated with sulphur.

Prof. Edw. D. Cope exhibited the skull of a whale from the Miocene of the Yorktown epoch. It adds another species to the whale-bone whales and established their descent from the Zeuglodonts. The elongation of the parietal and frontal bones is characteristic. The form is allied to the genus Cetotherium and is described under the name Cephalotropis coronatus.

GEOLOGICAL SOCIETY OF WASHINGTON.

At the 49th meeting held May 13, the following communications were presented:

The Faunal Relations of the Eocene and Upper Cretaceous on the Pacific Coast. T. W. Stanton, U. S. G. S. The Chico-Tejon series has been described as a continuous series showing a gradual transition both faunally and stratigraphically from the Cretaceous into the Eocene, the close faunal connection being found especially in the "Martinez group" (an upper sub-division of the Chico) and in "Intermediate beds." A study of the faunas and stratigraphy, especially in middle California, has proved that the intermediate beds and the upper part of the Martinez group are identical and that they form a lower zone of the Tejon, or Eocene. When the line between the two formations is thus located their faunas are but little more closely related than the Upper Cretaceous and Lower Eocene faunas of other parts of the world. With the exception of an ammonite, of which a few specimens were reported from the Tejon in early collections, the few species that seem to be identical in the two formations are persistent types that have come down to the present day with little change.

The structure and age of the Cascade Range. J. S. Diller, U. S. G. S. The two sections of the Cascade range afforded by the Klamath and Columbia rivers expose volcanic rocks only, and indicate that the range where most typically developed is composed essentially of lava from top to bottom. As far as yet known it has no core of older metamorphic rocks on which the line of volcanoes developed.

The auriferous slate series occurs on the western slope of the Cascade range about the head of the Umpqua where it is impinged by the Klamath mountains. These older rocks belong to the Klamath mountains. They strike northeast towards the Blue mountains of eastern Oregon and make a large angle with the general trend of the Cascade range.

At Ashland in southern Oregon, the relation of the Cascade range to the Klamath mountains is better exposed. They are separated by Rogue river valley which is cut chiefly in Cretaceous strata. Overlying these with apparent conformity and dipping gently to the eastward beneath the Cascade range are similar sedimentary rocks containing silicified wood, referred by Mr. Knowlton to a period certainly later than the Cretaceous. Above these and conformable with them on the western slope of the Cascade range are numerous sheets of lava and tuff. A tuff near the base of the series contains Miocene leaves. Although the volcanic activity of the Cascade range may have been initiated in earlier times, the period of greatest eruption and the upbuilding of the range occurred during the Neocene.

An early Date for Glaciation in the Sierra Nevada. Willard D. Johnson. The author described the occurrence of striated pebbles, of foreign material, in the extensive andesite-tuff flows, or volcanic mud flows of the Sierra, and gave reasons for regarding the striation of these included pebbles as probably glacial. He then called attention to a certain anomalous topography of the summit region of the range, and

offered for it an interpretation which, together with the presence of the presumably glacial pebbles in the deeply canyoned lavas, appeared to warrant the inference that glaciation here had a beginning coincident with the erection of the Sierra Nevada into a high range.

W. F. MORSELL, U. S. Geol. Survey.

At the 50th meeting of this society held in Washington, D. C., May 27, the last meeting until next fall, papers were read as follows:

The Structure and Texture of Soils. Under this title Prof. Milton Whitney, of the U. S. Department of Agriculture said:—The following forces are usually spoken of as the principal ones in the disintegration of rocks and the formation of soils. 1. Changes of temperature. 2. Moving water or ice. 3. Influence of vegetable or animal life (shades the land; admits air; solvent action of the roots; chemical action of decaying organic matter, earth-worms, and bacteria). 4. Chemical action of air and water. 5. Oxidation and hydration. Attention was called to the fact that all of these forces, except the solvent action of water and hydration, are largely superficial and would not act at any considerable depth. They certainly can not explain the disintegration of rocks to a depth of 50 or 75 feet as is seen in the crystalline areas at the South. It is an interesting fact that soils contain on an average about 50 per cent. by volume of interstitial space. If the solvent action of water has been the main cause of the disintegration of rocks, then 50 per cent. of the rock must have been dissolved and carried away. If the rock has been split up by mechanical means into the minute grains of sand and clay then the resulting material must have swelled to twice its original volume. Lantern slides were exhibited showing the shape of soil grains and the relative size and surface area. These were used to illustrate some of the physical properties of sand and clay. Slides were also shown illustrating the texture of soils and the economical importance of this subject in the distribution of crops was pointed out, the texture of soils adapted to many of the principal crops being shown. By the structure of soils is meant the arrangement of the soil grains. This has an important geological bearing and a very important economic side. Slides were used to show grains of soil unflocculated as they exist in a puddled clay and flocculated as they exist in a loam soil. The effect of this on the relation of soils to rain fall was explained and the economic importance of the difference in the conditions maintained by the soils owing to the difference in the structure was pointed out.

Topographic Nomenclature of Spanish America. Mr. Robert T. Hill of the U. S. Geological Survey, read a comprehensive paper upon the names given by the Spanish people to the topographic features of the United States, accompanying each kind by a definition and appropriate lantern illustration. It was held that with one or two exceptions Spanish words could be found upon the published maps for nearly all topographic forms. Over fifty of these terms were defined and illustrated, and Mr. Hill proposed that many of them be adopted into the English language, and used for forms for which the latter possesses no appropriate term. The paper will be published in full.

W. F. MORSELL, U. S. Geol. Survey.

NEW YORK ACADEMY OF SCIENCES.

May 18th, 1896. The Academy met with president Stevenson in the chair. The section of Geology and Mineralogy at once organized. The first paper of the evening was by Mr. Heinrich Ries, entitled "Notes of a Trip through the Marble quarries of western New England and eastern New York."

Mr. Ries sketched out the geology and geographic distribution of imestone quarries along the Hudson and Lake Champlain valleys, pass-

ing north, and the marble quarries in the Green mountains and Berkshire hills, coming south. His remarks were copiously illustrated by the lantern and by many beautiful specimens. The paper was discussed by Messrs. Martin, Dodge and Kemp, to whose remarks the speaker replied.

The second paper of the evening was by J. F. Kemp on "The great Quartz Vein at Lantern hill, near Mystic, Conn.

The speaker described the vein as about 400 ft. in width and at least 1,200 ft. in length. Its northern extremity forms the summit of Lantern hill about 500 ft. above sea level. This portion is of hard milky white quartz. The southern extension of the vein forms Long hill. It is lower in altitude and largely composed of loose, pulverulent quartz, which, however, perfectly preserves the comby structure of the quartz vein. It consists of innumerable interlocking masses of quartz crystals. It is but slightly iron stained in a few spots. It is so soft that it can be crumbled between the fingers and is easily dug with pick and shovel without any blasting. The vein strikes north about 15 degrees east and cuts squarely across the laminations of the gneiss. It is one of the largest quartz veins known in the east and is of very pure silica. Samples from the crumbly portion range from 98 to 99.4 SiO_2. A few rare scales of some migaceous or chloritic mineral are practically the only other ones present. Under the microscope the powdered quartz appears quite fresh and exercises a vigorous influence on polarized light. Some prism faces of quartz crystals show etched figures, but in general the evidence of corroding alkaline solutions is hard to find. The speaker was therefore led to refer the pulverulent character of the vein to the effects of a faulting or crushing movement, although he inferred on the spot the action of some corroding alkaline solution, presumably magnesian. The paper was discussed by Messrs. Dodge and Hovey.

The third paper of the evening was by J. F. Kemp and was entitled "The Pre-Cambrian Topography of the Adirondacks."

The speaker mentioned the curious outliers of Cambrian and Ordovician strata that have been discovered far up in the mountains from the main outcrops that skirt them. They lie in valleys in metamorphosed crystalline rocks, which valleys represent beyond question the old pre-Cambrian river valleys and which were filled with sediment by the encroaching sea of Cambrian and Ordovician time. Lake George is the largest example of this kind and contains remnants of Potsdam sandstone and Trenton limestone in its southern portion. The valley of Trout brook, which lies just west of Rogers rock at the north end of lake George and is separated from it by a high intervening ridge of gneiss, contains two outliers of Potsdam sandstone of a few acres in extent. In the valley of Putnam's pond in the western part of Ticonderoga township there is another outlier of Potsdam sandstone. Both of these are shown on the map of Ticonderoga which accompanied the speaker's report to Prof. James Hall on this region, published in 1895. Another isolated area of Calciferous limestone, is found on Schroon lake, under Schroon Lake post office. It is a few acres in extent and the exposed rock is about 75 ft. thick. It is 850 ft. above tide at its upper point. Down the lake and river valley it is nearly forty miles to the next Cambrian outcrop, which is below Hadley. The speaker also cited the little outlier of Trenton limestone near Wells on the Sacondaga river and the fact that the Cambrian and Ordovician sediments on the west side reach short distances into the areas of the crystalline rocks along the river valleys. He stated that all the outliers on the east side had a uniform northeasterly strike and a dip of 10 to 20 degrees to the northwest. He remarked that they occurred in the valleys of streams which are notably sluggish, explaining their slow movement by the fact that they flow in pre-Cambrian valleys, already nearly reduced

to a base level. He referred their parallel strike and dip to the general warping of the surface in this region. Remarking the undoubted presence of faults in the later development of the topography he emphasized the evidence of this early erosion long before the time of the fossiliferous sediments. He added that the old river valleys had in part been determined by the presence of crystalline limestones. The paper was discussed by Messrs. Dodge and Hovey.

The last paper of the evening was by L. M. Luquer and H. Ries and described an area of Augen-gneiss near Bedford, N. Y. It was read by Mr. Luquer and will appear in full in the Transactions.

The gneiss appears to have been originally a granitic rock that has been extensively crushed and sheared out into the Augen structure. The original quartz has been mostly comminuted, but the Carlsbad twins of orthoclase, have remained as augen.

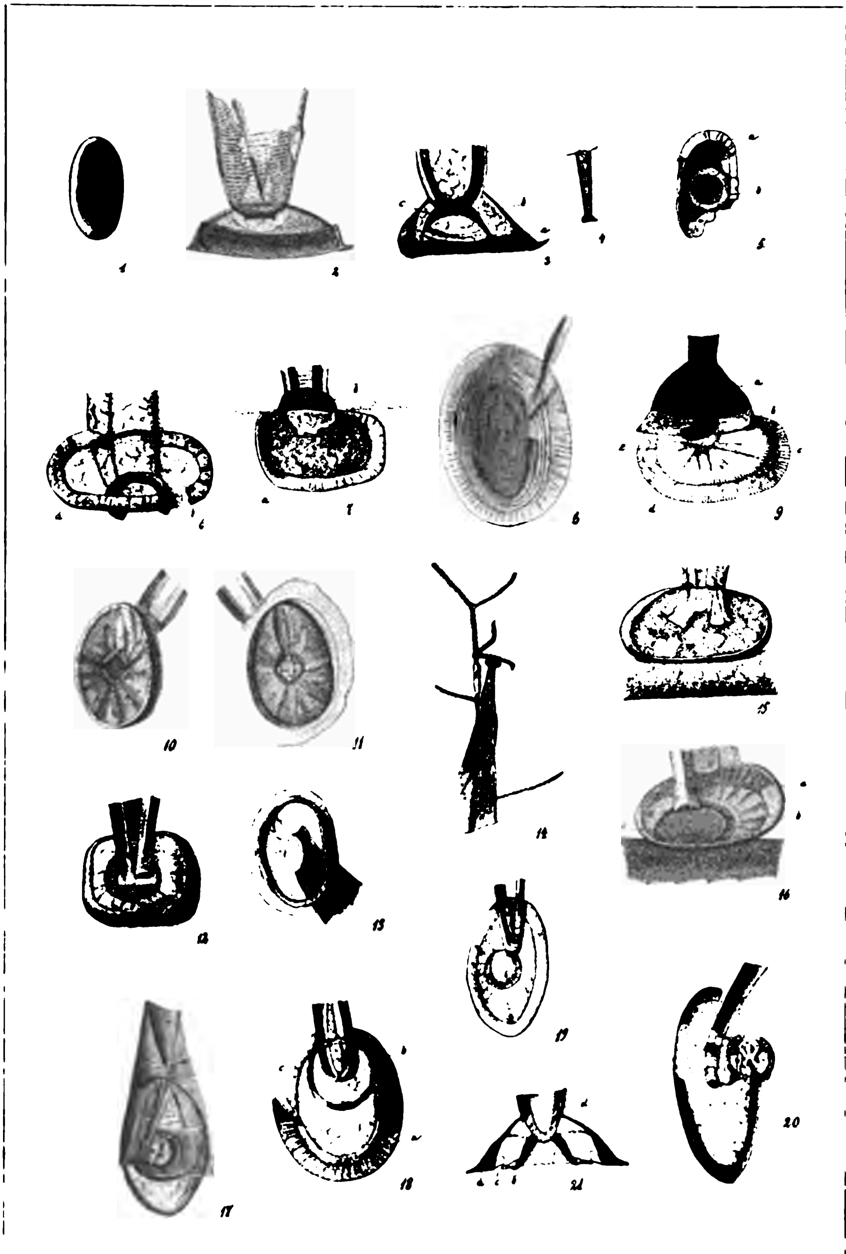
The paper was discussed by Dr. E. O. Hovey, who cited the case of the sheared Eisenach quartz-porphyry in which the feldspars have been crushed, but the quartzes have been drawn out.

Mr. G. F. Kunz mentioned the following items as the meeting closed:

THE OTTAWA, KANSAS, METEORIC STONE. A meteoric stone weighing 31 ounces was seen to fall by Mr. J. F. Black, April 9, 1896, at 6:15 p. m., on his farm 9 miles east and one mile north of Ottawa, Kansas. This meteorite contains iron particles throughout and is of the characteristic stony variety.

A REMARKABLE NUGGET OF NATIVE SILVER weighing 448 ounces troy, was found five miles from Globe City, Pinal county, Arizona. The mass is a water-worn nugget, slightly oval, very compact, and on its surface is bright silver-white, showing that it is made up of strings of crystallized silver, whereas the interior of the entire mass contains more or less cerargyrite. It has been presented to the Lea Collection of American Minerals of the United States National Museum.

NEW ZEALAND promises, mineralogically, to be a country of surprises, and many interesting things are being brought to light by the agate hunters from Oberstein, Germany, who are visiting it. Recently they have discovered some immense masses of rolled, rutilated quartz, weighing from 10 to 30 pounds each. The masses are penetrated by crystals of rutile, red, brown and yellow, many inches in length and of the fineness of hair. Occasionally the rutiles occur very sparingly; then again they are in such profusion as to give the entire mass the appearance of being a matted mass of hair. One mass of 30 pounds was entirely of this character. A fifteen pound mass contained a dozen or more crystals of rutile nine inches in length and from one-half to two mm. in diameter. Magnificent crystals of amethyst have also been found, one of which is entirely of gem-cutting material and weighing 550 pennyweights, or 27½ ounces troy. Topaz, blue and white, is found in the same localities. J. F. KEMP, Secretary.



SESSILE CONULARIA.

THE

AMERICAN GEOLOGIST.

VOL. XVIII. AUGUST, 1896. No. 2.

NOTE ON THE DISCOVERY OF A SESSILE CONULARIA.—ARTICLE II.

By R. RUEDEMANN, Dolgeville, N. Y.

(Plate II.)

After having presented* the general features of the occurrence of a sessile *Conularia*, the writer intends now to describe the most novel part of the fossil, i. e., the basal appendage.

Though an attempt to isolate and decolor some of the appendages failed, partly on account of an obscure cleavage in the rock and partly on account of the consistency of the residuum after the treatment with acetic and hydrofluoric acids, the author succeeded at least in developing, by the application of the same agents, several of the stout chitinous appendages on the slabs (cf. figs. 5 and 16). The defects in the preparation of the material are atoned for by the well-preserved state of the material itself, for several of the bases are preserved in neat natural sections (cf. figs. 2 and 3), a comparative study of which—as well as of the varying aspects of the other bases—allows a fair insight into the structure of this interesting organ. In order to enable the reader to form for himself a picture by a comparison of the different states of preservation, the writer has given as many sketches as possible.

*AMER. GEOL., vol. XVII, pp. 158, March, 1896.

As already stated in the first article, most bases appear at first sight as stout subcircular to suboval chitinous rings* (cf. pl. II, fig. 1, which is the base of the specimen reproduced on pl. IX, fig. 1, *op. cit.*). The original form was probably circular, as the elongated forms (cf. fig. 20) are generally found near the edge of the supporting fossil (cf. pl. VIII, figs. 1 and 2), where they were more liable to become laterally compressed than those on the inner part of the fossil.

The dimensions of those rings which are found still attached to a *Conularia* are: diameter from 1 to 2 mm. (original of fig. 1. pl. II, measures 1.3x.7 mm.; original of fig. 19, 1.75x2 mm.), though a few larger separate ones have been found (one measuring 4 mm.): hight .3 mm., (taken from the originals to figs. 1, 2 and 3).

Externally the ring is perfectly smooth and shining (fig. 1), expanded more or less abruptly towards the base (cf. figs. 2, 3, 13, 18). Underneath it possesses a system of regular radial folds (cf. figs. 7, 8, 9, 13, 18). The true nature of the rings is revealed by a few vertical sections which were found on some slabs (cf. figs. 2 and 3). Fig. 2 is a reproduction of the whole fossil, which is interesting because it demonstrates not only the occurrence of basal appendages detached from the extraneous object, but also the common separation of the pyramid of *Conularia gracilis* from the appendage a little above the latter. As both sections are not quite median, part of the ring

*These rings have been observed by A. G. Nathorst as early as 1882 (cf. A. G. Nathorst, "Om förekomsten af *Sphenothallus* cfr. *angustifolius* Hall i silurisk skiffer i Vestergötland" in Geologiska Föreningens i Stockholm Förhandlingar, vol. 6, p. 315, pl 15). The same author has published this year, in the April number of the same journal (vol. 18, no. 4), under the headline of "*Sphenothallus* en *Conularia*," a review of the study of this interesting fossil in Sweden, from which it appears that he, in describing in the first cited paper—a specimen of *Sphenothallus* Hall from the Silurian shale in the neighborhood of Våmb in Westgothland, accepted Hall's interpretation of the fossil as an alga. Some years later, however, another specimen was sent to him by Dr. N. O. Holst, the state of preservation of which was such as to convince Nathorst at once of the impossibility to refer the fossil to the vegetable kingdom. He pointed out this fact to Holst, who afterwards sent the same specimen to J. Chr. Moberg for identification. The latter reached the same conclusion, as appears from an extract of a letter of his to Nathorst: "It seems to remind me somewhat of a *Conularia*, and above all it surely was not any alga." Nathorst himself accepts now the identification of *Sphenothallus* with *Conularia*. Hall's type is not so well preserved as to have been able to suggest a comparison with *Conularia*.

is seen from the inside. In both, the ring becomes attenuated toward the top (in fig. 2 abruptly) thus forming a skin which fastened the basal appendage to the pyramid. This skin formed a dome above the ring, as may be inferred from the laterally compressed specimen reproduced by fig. 9, at *a*: *b* is the basal ring, which on account of its bulging out a little more, adheres to the counter part of the fossil. The general form of the appendage may be compared to a bell, which term will be applied in this paper to the exterior chitinous wall of the organ under consideration, as the word does not imply any expression regarding the possible functions of the whole.

Fig. 10 reproduces a specimen (taken from the original to pl. VIII, fig. 2), which gives a view of the inside of the dome of the bell and exhibits irregular radial wrinkles of the skin, caused probably by shrinkage prior to fossilization. In fig. 12 a base is seen from above. Here the greater part of the ring is preserved, while the upper portion of the bell left only its impression.

As appears from fig. 8, which reproduces the view allowed by one of the appendages into the bell from beneath, the latter—or at least its thicker basal part—consisted of concentric layers.

The absence of any carbonaceous film at the base of the bell (cf. figs. 7, 8, 13) would lead to the conclusion that the bell was open there; but the smooth surface of the rock inside of the deeper impression of the ring (cf. fig. 9*d*) in several specimens indicates the former existence of a basal closing film. A very clear view of the latter is furnished by the basal appendage (cf. fig. 15) of the *Conularia* reproduced in fig. 14, which apparently was attached to a little fragment of a *Stictoporella*. It appeared at first like fig. 15; the dissolving of the enclosed rock, however, brought out the entire base of the organ, namely, the broad, deeply-impressed exterior ring (*a*), the impression of the somewhat wrinkled film (*b*) stretching towards the center of the base and connecting with an internal part (*c*) that appears as a narrower radially furrowed impression of a ring. The latter can be seen very distinctly at the bottom of the basal appendage reproduced by fig. 1. In the remarkable specimen belonging to fig. 6, all chitinous parts have been removed by weathering except two

stout rings, which strongly contrast with the buff-colored weathered shale, and which are evidently the bases of the bell and of an internal part of the appendage. Also the original to fig. 5 (taken from the group pl. IX, fig. 7) exhibits a stout, though now, through the action of the acids, somewhat corroded ring. Another reproduction (fig. 7) of the underside of a basal appendage shows the latter removed from the center, apparently by the overturning of the young *Conularia* to which it was firmly attached. It is partly preserved in the original of fig. 9, and it can be distinctly seen in the basal appendage reproduced in fig. 13 (taken from the group pl. VIII, fig. 5), where it stands out in relief, while its system of basal radial furrows can be seen in fig. 18 at *b*.

The real form of this internal body is revealed by a fine vertical section through the basal appendage (fig. 3) of a detached *Conularia* (fig. 4). This section shows a crescent-shaped cleft again of a stout chitinous body, proceeding from the converging marginal grooves of the pyramid of *Conularia*. The horns of the crescent can be traced to the chitinous mass of the basal ring of the bell, the inside of which is visible in the section. The original to fig. 5 assists in making evident that this crescent is the section of a chitinous cup-shaped body, which is fastened to the apex of the pyramid, while its base is continuous with the basal skin, extending to the exterior bell. The cup itself was not closed basally, as it can be inferred from the little node in the center of the impressions of the basal appendages (cf. fig. 9*d*).

It remains to consider the connection of the pyramid of *Conularia* with the basal organ. As the sections figs. 2 and 3 indicate, the angular grooves of the pyramid curved in at the basal end. The subquadrangular piece broken out of the dome of the bell in fig. 10 suggests that the shell of *Conularia* yet retained its quadrangular section when entering the bell. The counterpart of this fossil (fig. 11) has preserved the broken-out chitinous piece and exhibits on the latter a cross of four ridges, consisting of pyrite. A similar aspect is presented by the node in the middle of the basal appendage of fig. 17, which is an enlargement of the base of the specimen reproduced on pl. VIII, fig. 4, and which shows two arms and the intersections of the two others on top of the central

node. The pyrite in both specimens points to the former existence of canals, or at least to an original difference between the material which has been replaced by pyrite and the enclosing chitine. There can hardly be any doubt that the cross of pyrite represents the basal junction of the marginal grooves of the pyramid, and that the little node in the center of the base (cf. figs. 11 and 17) is the real apex of the pyramid. The direct continuance of at least two grooves is exhibited by quite a number of remains, e. g., by those reproduced in figs. 18 and 19, while the original to fig. 20 gives a neat section through the four grooves at the entrance of the pyramid into the bell. It is evident from the latter fossil that these grooves, as already demonstrated in the first article, were originally covered by a carbonaceous film and filled with phosphate of lime. The supposition is, therefore, not out the way, that they may have been free from this filling towards their proximal ends and could therefore have been filled by pyrite during the process of fossilization.

The morphology of the whole appendage will be best understood from a diagrammatic section, as given in fig. 21. The apex of the pyramid (*d*) is enclosed in a stout central cup (*b*), which, in turn, is connected by a thin film (*c*) with the broad basal extension of the exterior bell (*a*). The latter again is fastened to the pyramid a little above the cup.

There can be no doubt that the basal appendage was an organ of attachment. It is further evident that the latter did not amount to a coalescence, but was of a temporary character only; for the not uncommon occurrence of detached specimens with well-preserved basal appendages (cf. figs. 2 and 4) is not consistent with the assumption of a coalescence. The apparatus, therefore, cannot be compared to the basal disks, such as certain bryozoans have. On the other hand, it is indicated by the impressions left by the appendages* that their inner parts were flexible or even retractible, while the stout exterior bell, with its broad, radially striated base, apparently served to give stability to the mechanism and to close the interior tightly from the exterior.

*Cf. figs. 16 and 9, which show the ring-like impression (*c*) of the bell to be considerably deeper than that of the wrinkled basal film (*d*).

An attempt to compare the basal appendages to suckers, such as various gastropods use for purposes of attachment, would lead to the further assumption that their interior was filled with muscular tissue, and consequently connected with the circulatory system of the living animal. The writer was unable to study this question on account of the negative results which followed his attempts to isolate the appendages; neither did he succeed in tracing the confluent canals, indicated by the cross of pyrite at the apex of the shell, which may have effected a connection with the interior of the pyramid and thereby have become instrumental in producing a vacuum by the withdrawal of a fluid, similar to that found in the pedicels of the echinoids. The writer, however, is inclined to suppose that there existed no connection whatever between the interiors of the pyramid and of the appendage, but that attachment was effected by the elasticity of the latter alone, especially by that of the central cup. The organ might then be compared to the chitinous suckers with which the males of certain water-beetles (e. g., *Eunectes*) are provided, and which possess no muscular tissue whatever but adhere to foreign bodies by external pressure and by subsequently resuming the original shape through their own elasticity, thus producing a vacuum much like the India rubber plates which are used to fasten objects to the glass plates of show windows. The shape of the central cup as well as the fact that the appendage consists of a substance which certainly was elastic, could be adduced in favor of this supposition, while there seems to be no serious obstacle in the way of assuming that the animal,—which no doubt had a certain power of free moving.—had the further power of pressing the apex of the shell and with it the securely fastened cup to the body it wished to adhere to.

The diagrammatic section, fig. 21, is intended to illustrate the working of the apparatus, the dotted part representing the latter in the state of compression preparatory to attachment, and the striated part shows the same in the state of attachment by suction.

It should be remembered that however erroneous the attempt to explain the special operation of this organ may be, this does not affect the fact that the attachment was evidently only a temporary one and that the impressions left by the

appendages show both, the connecting film and the central cup bulging inward. These observations can, in the opinion of the writer, be only accounted for by the assumption that the basal appendage was an organ of attachment by suction.

EXPLANATION OF PLATE II.

Conularia gracilis Hall. Utica shale, Dolgeville, N. Y.

FIG. 1. Dorsal view of basal appendage. Enlargement of the appendage of the specimen reproduced in pl. IX, fig. 1. ×10.

FIG. 2. Vertical section through appendage. Whole specimen as found. ×10.

FIG. 3. Nearly vertical section. *a*, basal ring of exterior bell, seen from inside: *b*, dorsal part of bell: *c*, interior cup. ×10.

FIG. 4. Detached specimen of *Conularia gracilis*, bearing the appendage reproduced by fig. 3. Nat. size.

FIG. 5. Underside of appendage. *a*, base of exterior bell: *b*, base of interior cup. ×10.

FIG. 6. Ventral view of appendage, only the bases of exterior bell (*a*) and interior cup (*b*) being preserved. ×10.

FIG. 7. Ventral view of appendage. *a*, base of exterior bell; *b*, base of interior cup. ×10.

FIG. 8. Ventral view of appendage, showing the radial furrows of the base of the exterior bell and the concentric structure of the latter. ×10.

FIG. 9. Lateral view of basal appendage. *a*, dome of bell: *b*, basal ring of bell; *c*, impression of base of bell: *d*, impression of basal skin: *e*, node in center, cast of central cup. ×10.

FIG. 10. Interior view of bell from ventral side, shows wrinkled dome of bell and subquadrangular entrance of pyramid of *Conularia*. ×10.

FIG. 11. Counterpart of the preceding. Shows the apex of the pyramid. ×10.

FIG. 12. Dorsal view of appendage. Dome of bell broken away. ×10.

FIG. 13. Ventral view of appendage. Shows radial striation of base of bell. ×10.

FIG. 14. *Conularia gracilis* Hall attached to a fragment of *Stictoporella*. Nat. size.

FIG. 15. The same. Basal appendage as found originally. ×8.

FIG. 16. The same. Matrix removed by acetic and hydrofluoric acids. *a*, interior bell; *b*, impression of connecting basal skin: *c*, impression of central cup. ×8.

FIG. 17. Ventral view of appendage. Exterior bell seen in section. Exhibits apex of pyramid. ×6.

FIG. 18. Ventral view of appendage. *a*, base of bell: *b*, base of central cup. ×10.

FIG. 19. Impression of basal appendage. Junction of two marginal grooves of pyramid preserved. ×10

FIG. 20. Transversal section through appendage. Shows the four marginal grooves of the shell of *Conularia* in section. ×10.

FIG. 21. Diagrammatic section through basal appendage. The dotted part is a section through the basal appendage in the state of compression, the striated through the same in the state of attachment. ×10.

PREGLACIAL EROSION CYCLES IN NORTHWESTERN ILLINOIS.

By OSCAR H. HERSHEY, Freeport, Ill.

INTRODUCTION.

There are three steps to be taken in the study of the geomorphology of the upper Mississippi basin. The first is the determination of the various cycles of erosion in the several districts as illustrated by the present topographic forms: the second is the correlation of the ancient baselevels of the different districts by comparison and by direct tracing; the third is the determination of the relation between the cycles of erosion in the geologic province and the cycles of deposition in the surrounding seas, as illustrated by marine deposits of a known age. It is the purpose of the writer in this paper to take the first step in one very limited district, namely, that portion of the state of Illinois which lies north and west of the Rock river. This district lies on the southern slope and near the base of the Wisconsin Uplift, is a more elevated area than the remainder of the state, and has been subject to epeirogenic movements of a greater amplitude. Furthermore, its rock formations are well indurated, and the glaciation of the region has had very little effect on its topography. Hence the study of the geomorphology of the state may well begin in this northwestern corner. Illustrations will be drawn chiefly from the Pecatonica basin, because that is the portion of the district with which the writer is best acquainted.

STRATIGRAPHY OF THE DISTRICT.

The indurated bed-rock formations of northwestern Illinois may be combined into the following general table:

	Thickness. feet.
Carboniferous sandstone and Devonian limestone......	
Niagara limestone..................................	200 "
Hudson River shales................................	85 "
Utica shales?......................................	14 "
Galena limestone...................................	200 "
Trenton shale......................................	5 "
Trenton limestone..................................	40 "
Pecatonica limestone...............................	40 "
St. Peter sandstone................................	200 "
Lower Magnesian limestone and shale, exposed........	10 "
Total..	794 feet.

The strata are nearly horizontal, the normal dip being to the south at the rate of a few feet per mile. But they have been thrown into gentle undulations of two systems. The first system consists of a number of low broad anticlinal and monoclinal axes sweeping across the district in a general east and west direction, but curving slightly toward the south. Crossing this system at an oblique angle, there is a less distinct northwest and southeast system. In addition to the above systems of a true Appalachian montanic type, there is a long broad structural elevation, commonly known as the Grand de Tour-La Salle anticlinal. This is the nature of the so-called Cincinnati arch, of which, in fact, it appears to be a continuation.

TOPOGRAPHY.

In order to obtain a correct idea of the topographic features of the district under discussion, we can do no better than to briefly describe a number of views taken from elevated stations within its limits.

View 1. Two miles northwest of the town of Lena, in Stephenson county, there stands an isolated "mound," long thought to be the highest elevation in the state. In ascending it, a splendid scene bursts upon our vision. Few people know the delight of looking down upon a cultivated plain from even so low an elevation as a "mound." This hill is about 150 feet in hight; and it stands on a plain which has at first a gently rolling surface, but at some distance, if we face the north or east, toward the Pecatonica river, it becomes rapidly undulating, being dissected by comparatively narrow valleys. Although it is a hilly country, all the hilltops rise to nearly the same hight and in the far distance merge into a perfectly even sky line. Looking southeastward, the apparent plain is seen to be broken by a single elevation, a "mound," six miles distant, consisting of several long and narrow parallel ridges, which rise to a maximum altitude of about 125 feet above the plain. Southward and westward the level plain is terminated by a long range of hills, which, if the atmosphere be hazy, will resemble a low mountain range, though only a few hundred feet high and twelve miles distant. At the northern end, this range of hills breaks up into several isolated cone-shaped mounds.

View 2. About two miles east of Galena, in Jo Daviess county, there is a "mound" which rises perhaps 200 feet above the general upland surface. Looking northwestward from its summit we see a sharply dissected plain, broken by no elevations within this state. But to the south and southwest a line of prominent "mounds" rise from 200 to 300 feet above the plane which passes along the hilltops of the ordinary upland surface. Eastward from us a very large portion of the country is occupied by long ridges and small plateaus, which rise from a dissected plain in the same manner and to a similar hight as the isolated "mounds."

View 3. This view is taken five miles northeast of the city of Freeport, in Stephenson county. We stand on a broad ridge and look across similar ridges to the north and east. But all the ridges are of the same hight, and within a few miles they merge into a perfectly even sky line. Tracing this line around by the west, we find it broken by a single cone-shaped mound; but, turning to the south, we look across a broad basin in which the hill tops do not rise to so great altitude as the ridge on which we stand. Ten miles distant, however, the surface again rises to the level of the hills immediately about us, and is apparently a portion of the same dissected plain. In the broad shallow basin, which intervenes between the higher ridges, we find that, were the valleys filled up to the level of the hills. we should have a plain, sloping rapidly from the ridges which bound it, but becoming nearly level in the central portion. While its level is 100 feet lower than the ordinary upland surface, it is still a very hilly country, for, trenched below the bottom of the ancient basin, there are comparatively narrow valleys, locally bounded by bluffs. The largest af these valleys is occupied by the Pecatonica river.

View 4. The divide between the hydrographic basins of Yellow creek and Leaf river is a broad ridge, at some places simulating a low, narrow plateau. Taking our position on its crest and looking southward, we see a broad valley or basin, several miles wide and bounded by a narrow ridge nearly as high as the one on which we stand. Trenched into the bottom of this basin are narrow valleys of the same system that we found in the Pecatonica basin. If we were to go southward across this basin to the ridge which bounds the view in that

direction, upon ascending to its summit we should look into a similar but broader basin, and beyond it to another high ridge in the distance.

During the first two views we stood on "mounds," and looked down upon a broad gently undulating and deeply dissected plain. During the last two views we stood on some of the ridges which compose this plain, and looked across lower, dissected, basin-like plains. It is evident that the topographic forms of the district fall naturally into four classes. There is apparently a well defined but deeply eroded peneplain, beneath the surface of which there have been excavated shallow valleys, so broad that they may be considered as another but imperfectly developed peneplain. The "mounds" rise above the first as monadnocks, and the bluff-bound valleys are trenched below the second, constituting the present cañon-like valleys of the streams.

Ancient Peneplains or Baselevels.

The writer recognizes five distinct preglacial baselevels in northwestern Illinois. As their age is somewhat uncertain at the present stage of the study, they will be designated by numbers.

Peneplain No. 1. The "mounds" of the lead region of Iowa, Wisconsin, and Illinois, consist of about 100 feet of Cincinnati shales, capped by from 25 to 150 feet of Niagara limestone. They do not all rise to the same altitude, but, in general, adjacent "mounds" have their summits nearly on a common level. Many of them are prolonged into ridges and broaden into narrow plateaus. The ridges have even crest lines, and the plateaus are flat. In short they impress one as being remnants of an eroded and slightly deformed peneplain. There are, however, several objections to the ready acceptance of this proposition. Especially it may be urged, from the presence of the capping Niagara limestone, that the apparent even plain of the summits is a structural plane due to a resistant stratum.

There is some evidence that a baselevel plain of erosion existed at or above the summit plane of the "mounds." They almost invariably stand over the synclinal axes of the district. This fact has been so generally recognized that some geologists have ventured to locate such axes by means of the

"mounds" alone. Now it is evident that, when the baselevel passed below the summit plane of the "mounds," the drainage systems were not in the synclinal troughs, but had been readjusted during some previous cycle so as to occupy the position of the anticlinal axes. This does not necessarily imply the presence of a peneplain, but, as studies in other portions of the continent have shown that such a readjustment of drainage systems is generally accompanied by the formation of a peneplain, we may presume that such was the case in our district also. It remains to determine, however, whether the "mounds" reach the level of the peneplain or are merely the worn down remnants of higher elevations.

The Niagara limestone in Iowa, adjoining the district occupied by the "mounds," reaches a maximum thickness of 350 feet. It thins slightly in all directions, but at least 200 feet of it is due over these elevations. Now in the central portion of Jo Daviess county, where there are plateaus exceeding one mile in width, less than half of this thickness of the Niagara formation remains. If the summit of the "mounds" is not an eroded peneplain, but due to the presence of the resistant Niagara limestone, we should expect their hight to be dependent largely on the width. For instance, a ridge of unequal width should have a serrated crest line. It is also difficult to understand the conditions under which subaerial erosion, acting on the summit of a ridge, could remove the larger part of a homogeneous hard limestone formation and finally leave it as a flat-topped plateau exceeding one mile in width. Indeed, the evidence is almost conclusive that the removal of the greater portion of the limestone was effected during a cycle in which the baselevel of erosion approximately coincided with the summit plane of the "mounds." The preservation of these remnants of the peneplain, to the present day, is due to the fortuitous circumstance of the baselevel bearing such a relation to the structural planes as to preserve strips of the Niagara terrane over the synclinal troughs, while the anticlinals carried the surface of the soft Cincinnati shales above the peneplain, constituting them lines of weakness readily seized upon by the streams.

It is not asserted that all the "mounds" of this district reach the level of the peneplain. The summit of many of the

cone-shaped elevations and narrow ridges has doubtless been lowered somewhat during subsequent cycles of erosion. In some cases the limestone cap has been entirely removed and the soft shales underneath have been worn down to a mere dome-shaped protuberance on the lower plain. But the flat-topped plateaus must attain a hight as near to that of the uplifted basal plane of erosion as do any of the ancient peneplains of America.

This peneplain No. 1, in northwestern Illinois, attains a maximum altitude at least 1,275 feet above the sea, as indicated by Charles Mound, in Jo Daviess county, the highest elevation in the state of Illinois. From here it slopes gently towards the south and southeast. The most eastern "mound" is situated near the village of Eleroy in Stephenson county. It is thirty miles east-southeast from Charles Mound and attains an altitude of about 1,075 feet above the sea. On this "mound" there remains only a thickness of about a dozen feet of the Niagara limestone, and we might suppose that its summit has been worn down far below the peneplain level. But all the "mounds" in Stephenson county rise to a plane which gradually ascends as it approaches Charles Mound and passes through its summit. Consequently, we may assume that the peneplain level is represented by the summits of the Stephenson county "mounds." We thus learn that not only is it depressed toward the southeast but it also approaches the plane which passes through the ordinary upland surface. In western Jo Daviess county the upper peneplain stands about 250 feet above the lower plain, while in Stephenson county the difference is only 125 feet. The preservation of many remnants of the peneplain in central Jo Daviess county is due to the considerable thickness of Niagara limestone remaining in the structural troughs at the close of the cycle. But the peneplain in passing eastward on the strike of the synclinal axes beveled the edges of the Niagara strata gently upturned by the Grand de Tour-La Salle axis of uplift. This accounts for the small amount of Niagara limestone remaining on the "mounds" of Stephenson county and also for its total absence in the country east of Eleroy.

At the close of cycle No. 1 northwestern Illinois was a low-lying plain of slight relief, with river systems adjusted to the

anticlinal axes or at least with the main divides in the position of the structural troughs. The altitude of the land at that period depended on the position of the sea coast, which was probably not far distant: and consequently we may consider the plain to have been practically at sea-level. The cycle was terminated by a slight uplift of the district, establishing a new baselevel of erosion, rejuvenating the streams, causing them to excavate new valleys, widening them until the divides had nearly disappeared as prominent topographic forms (except the "mounds"), and finally completing the new peneplain which we shall next consider.

Peneplain No. 2. While some slight doubt may remain concerning the presence of a peneplain passing through the summit of the "mounds," none whatever can be entertained as to the nature of the plain at their base. It is the most characteristic topographic feature of this district and is a true basal plain of erosion. Although it corresponds throughout a large portion of the district with the surface of the Galena limestone terrane. it is unaffected by the structural folds of the indurated formations. In Stephenson county it passes within six miles from the surface of the Galena limestone, through 100 feet of Cincinnati shales and well into the lower portion of the Niagara formation. Continuing south on the same line into Ogle county, in six miles farther it has again beveled the edges of the gently inclined Cincinnati strata and cut away half of the Galena limestone. Fifteen miles southeastward it coincides with the surface of the St. Peter sandstone. In the vicinity of the Mississippi river it passes through the gently inclined strata of the Galena, Cincinnati, and Niagara formations, and always maintains a nearly even surface.

At the foot of the "mounds" this peneplain is usually well preserved as a level plain: but in approaching the main lines of drainage it has been deeply eroded and remains only as widely separated, gently sloping ridges. One of these ridges terminates in the high rock ridge on the western side of the city of Freeport. Northward from it the country rock is the Galena limestone, and beyond the Pecatonica valley the first remnant of this peneplain is a higher upland ridge about three miles distant. But southward from it, where the soft

Cincinnati shales still remained in considerable thickness at the close of cycle No. 2, the peneplain is represented by no ridge until the base of the Niagara limestone passes below its level six miles south. Thence to the Rock river this base-leveled plain remains only in long, narrow ridges, several miles apart, and occupying the position of the synclinal axes. Indeed. the regular deformations of the rock strata can be determined as readily by a study of the ridges which constitute the remnants of peneplain No. 2 as by the "mounds."

In the country eastward from Freeport, the uplifted peneplain which we are now considering is represented by a broad ridge on the Stephenson and Ogle county line; and ten miles north it forms a hilly upland described in view 3. The basin between these higher upland areas widens toward the east until it constitutes the greater portion of the upland surface. In the vicinity of the preglacial valley of Rock river, peneplain No. 2 has been completely destroyed, as also for many miles back from it. But outside of the immediate valley of the stream, the surface is an eroded upland plain resembling that of western Stephenson county; and, at first thought, the much lower altitude of the upland near Rock river than of the general surface in the more western portion of the district might be attributed to a tilting of the peneplain toward the east. Such tilting has occurred, but not to the amount that a casual survey of the region would indicate. Even in the eastern portion of Stephenson county, where both upland plains are well represented, some confusion might be experienced in separating the upland surface into two classes; for the ridges which make up the lower upland are but little lower than the remnant ridges of peneplain No. 2 along the edges of the basins, while the former gently decline in a graceful curve and the two reach the Pecatonica valley proper at an equal hight. All the higher upland ridges form a perfect plain sloping gently to the southeast. The inclination is regular, and by projecting the plane across the Rock river valley it is found to be at a considerable hight above the general upland surface. Proceeding on a meridional line southward from Freeport, the same gentle declination of the peneplain is indicated by the higher ridges; and, projecting its plane across the upland near Rock river, it is found to be

at a greater hight than is attained by any of the ridges there. In short, we have abundant evidence that peneplain No. 2 has been entirely destroyed throughout the country near the ancient Rock river, and that the upland there found is a later and lower eroded peneplain.

The present altitude of peneplain No. 2 in northwestern Illinois reaches a maximum, near Warren in Jo Daviess county, of 1,015 feet above the sea. This is apparently on a north and south axis of deformation of the peneplain, for both eastward and westward from it there is a gentle descending slope of the upland surface. Near the Mississippi river it slightly exceeds 900 feet above the sea, and in the Rock river valley its altitude is about the same. Indeed, on the Wisconsin line, the peneplain for a score of miles both east and west from Warren keeps well up to the 1,000 foot level. There is a gentle descent southward at the average rate of three feet per mile: Furthermore, there is an east and west slope from the above mentioned axis of deformation, which trends northwest to southeast nearly in the position of the axis of the Grand de Tour-LaSalle uplift. Along this structural ridge, the peneplain, after crossing the state line near Warren at 1,015 feet, still maintains an altitude exceeding 900 feet where it crosses the present Rock river between Oregon and Grand de Tour. At Freeport the peneplain is about 925 feet above the sea; and at Rockford, 28 miles east, though none of the ridges in the vicinity quite reach its level, it may be placed approximately at 850 feet. There is thus a very gentle inclination of the peneplain on the northeast slope of the structural ridge above mentioned; but from its summit it slopes more rapidly toward the southwest. I have not the data for definitely determining its altitude in the southwestern portion of the district, but should locate it at Savanna as about 900 feet above the sea, and at Rock Island as 800 feet.

At the close of cycle No. 2 northwestern Illinois was a nearly perfect plain, sloping very gently toward the nearest sea coast and surmounted by about a score of slight elevations, some isolated and others grouped into clusters of hills. The altitude of this peneplain depended on the distance to the sea. As its age has not yet been determined, we cannot say where the coast stood during this cycle. We will assume

that the streams which baseleveled our district flowed into the sea at the head of the Mississippi embayment. Approximating the distance as 400 miles, and allowing a gradient of two inches as a minimum and five inches as a maximum per mile, we should arrive at an altitude for the plain in the position now occupied by the city of Freeport of respectively 66 feet and 166 feet. The latter figure is probably more nearly correct than the former, and by adding 275 feet for the maximum hight of the "mounds" we should have 441 feet above the sea as the altitude of the highest point of our district (and probably of all districts in the present state of Illinois) at the close of cycle No. 2. Although little reliance can be placed on the accuracy of the foregoing (and subsequent) estimates of the altitude of northwestern Illinois during different erosion cycles, they may be considered as indicating, in a general way, the amount of elevation during each uplift of the region. It is proposed to prove that our district was uplifted by a series of movements of elevation, perhaps epeirogenic in quality, culminating at the close of the five preglacial erosion cycles. If there were movements of depression, their record has been destroyed by subsequent erosion.

Peneplain No. 3. The main features of this peneplain have been already described. It is only quite recently that the writer first recognized its existence. As suggested before, many observers on a hasty reconnoissance of the region might deny its existence entirely. But upon proceeding eastward from Freeport and taking a position on the bluffs of the Pecatonica valley, the facts can not be controverted that all the ridges adjacent to the present cañon-like valley rise to the same hight, which is about 80 feet above the river level; and that this hilltop plane is about 100 feet lower than the ordinary upland surface several miles back from the river. These 80-foot ridges undoubtedly represent a base level of erosion. The peneplain of the higher upland ridges, the basin-like valleys above the level of the 80-foot ridges, and the present cañon-like valleys, are all carved from a homogeneous formation, the Galena limestone. Furthermore, the facts that similar broad and shallow basins have been excavated below the surface of peneplain No. 2 throughout the region, and that the bottom of these basins always bears about the same rela-

tion to the higher peneplain and to the present water level, are strong presumptive evidence that they indicate the position of an uplifted baselevel of erosion.

The depth of the basins averages 100 feet throughout the district. Their width was dependent not only on the size of the stream but also to a certain extent on the nature of the rock excavated, and to a less extent on the position of the synclinal axes. While the Pecatonica river above Freeport eroded a basin only about three miles wide in Galena limestone, its tributary, the ancient Yellow creek. excavated a basin four to five miles wide in Cincinnati shales. In the same formation, however, the size of the basins is proportionate to the size of the present streams. In the vicinity of the main lines of drainage, like that of the ancient Rock river. the basin was very broad and the central portion of it a flat plain miles in width (a true peneplain though a narrow one); but, in ascending to the headwaters of the streams, these basins narrow until they become mere gentle slopes of the upper portion of the present valley sides. This is their nature throughout a large part of the southern portion of the Driftless Area in Jo Daviess county, Illinois. But even here the rather abrupt change from a gentle slope to a nearly perpendicular bluff face will impress one as indicating a baselevel of erosion.

Assuming the existence of an uplifted erosion plane at the level of the lower upland ridges as demonstrated, we find that its present altitude at Freeport is 820 feet above the sea. It is represented in the city by the ridge on its southern edge, which ridge is overlooked by the remnant of the higher peneplain constituted by the western ridge before mentioned. I have not the data for accurately locating its altitude in any other portion of the district. If it always coincided with the summit of the valley bluffs, its altitude could be determined by adding the known hight of a bluff to the altitude of the stream at its base. On this principle I should locate baselevel No. 3 near Rockford as 780 feet above the sea; at Galena, 800 feet; at Savanna, 800 feet; at Rock Island, 700 feet; at Sterling, 750 feet: and at Oregon, 800 feet. But as there is usually a short slope from the summit of the ridges which form the eroded peneplain to the top of the bluff proper, the above altitudes are probably somewhat below the true hight.

At the close of cycle No. 3 northwestern Illinois was a gently rolling plain. The general upland surface was about 100 feet above the broad plainlike valleys of the larger streams. We cannot say that the sea coast during this cycle of erosion was more distant than during the preceding one; and, as the larger valleys were a perfect baseleveled plain, we will assume the same drainage gradient for the streams of this cycle. Assuming the difference in altitude of the two peneplains to be the actual amount of uplift, we obtain a maximum altitude for our district at the end of cycle No. 3 as 541 feet. The average upland altitude would be 266 feet above the sea level of that time. It is possible that our estimates for this cycle are too low, as the streams, meandering on the broad flood-plains of the valleys, were doubtless much longer than the basins in which they flowed.

Baselevel No. 4. The present valleys of the streams of northwestern Illinois are comparatively narrow, flat-bottomed troughs. The sides are frequently very steep, occasionally precipitous walls of bare rock. These bluffs vary from a hight of 80 feet in the lower Pecatonica valley to 250 feet along the Mississippi river. There are 200-foot bluffs along the Rock river between Grand de Tour and Oregon, but the stream is out of its old course and these bluffs are not preglacial, so that they do not affect the present discussion. The width of these valleys varies according to (*a*) the size of the stream flowing in them, (*b*) the nature of the rock excavated and (*c*) the depth of the gorge. The soft Cincinnati shales give broad valleys with gentle slopes; the Galena limestone permits much narrower valleys, with distinct bluffs and mural precipices; the Niagara limestone forms slightly narrower but otherwise similar valleys; and the St. Peter sandstone has much narrower gorge-like valleys, with steep bluffs but rarely precipitous cliffs. The moderately resistant properties of the St. Peter sandstone in Illinois are finely illustrated in the Elk Horn creek valley in Ogle county, where a fault with a throw of 40 feet crosses a small valley. On the upstream side of the fault the valley is excavated into Galena and Trenton limestones and is broad and open; but, where the fault brings the St. Peter sandstone above the valley plain, it suddenly narrows to a gorge less than one-third as wide as it is above the fault.

The same difference is observed in the Pecatonica valley. Where it is excavated into the Galena limestone the valley is from one to two miles wide; but upon following it into Wisconsin onto the St. Peter sandstone terrane it becomes a narrow cañon-like trench.

It is chiefly to the depth of the gorges that they owe their width. In Stephenson county where the bluffs rarely exceed 80 or 100 feet in hight, the valleys are comparatively broad and do not resemble gorges. The same system of valleys excavated into the same formation in Jo Daviess county, but to a depth twice as great, become narrow-cañon-like troughs with many rocky precipices.

The bottom of these rock troughs is far below the present water level. Well-sections in the preglacial valley of the Mississippi river at three places have reached the rock-floor of the valley at depths below the present low water level as follows:* Dubuque, Iowa, 182 feet; Sabula, Iowa, 143 feet; and Fulton, Ill., 101 feet. I have been unable to secure very satisfactory well-sections over the deeper portions of the valleys within this district, but several near the south side of the Pecatonica valley at Freeport penetrate to depths of 100 feet before reaching rock. Outside of the district but within a moderate distance from it. there are well-sections which indicate the rock-bottom of the ancient Rock-Illinois valley as follows:† On the border of lake Koshkonong, Wis., 330 feet below the Rock river; at Janesville, Wis., 250 feet below the same river; and in an abandoned channel at Princeton, Ill., the rock surface is about 165 feet below the present water level.

It is evident, from the above sections of wells on both sides of our district, that the rock-floor of the valleys is at least 100 feet, and in the extreme northeastern portion possibly 200 feet, below the alluvial plains of the present streams. I have found what I believe to be evidence that the erosion of these cañon valleys was effected in two stages. The evidence consists chiefly of a rock shelf buried 20 feet under the river level at Freeport. A comparison of the topographic forms of

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*From a table published by F. Leverett, Journal of Geology, vol. III, No. 7.

†Chamberlin and Salisbury, Sixth Annual Report, U. S. Geol. Survey.

the portion of the valley above the flood-plain with that under it, so far as the latter can be determined by well-sections, indicates that the bluffs were formed during a cycle of erosion when the streams flowed at a level, at Freeport, 20 feet lower than the present water level. The existence of the rock-shelf at Freeport is undoubted, but in other portions of the district the evidence rests largely on the fact that, while the bluffs above the present stream level are frequently precipitous, their buried portion has often a moderate slope. Nor is this sloping basal portion of the bluff a talus, for the wells upon reaching it penetrate solid undisturbed rock strata. Now a perpendicular bluff in such a formation as the Galena limestone can only be produced by the undermining of its base by a stream. Hence, the base of the bluff indicates the stream level during its formation, and the slope below belongs to a succeeding cycle of erosion.

While the evidence of the existence of a rock-shelf a short distance below the present alluvial plains is not conclusive in the greater portion of the district, it appears to the writer to be so in the vicinity of Freeport. And as the rock-shelf at the latter place can hardly be an isolated phenomenon, it may be assumed that it is represented in some form or other and in some position throughout the district and probably far beyond it.

At the close of the cycle No. 4, what is now northwestern Illinois was a dissected gently rolling plain with topography essentially as now. As the valleys whose excavation was accomplished during this cycle were many times wider than the streams which flowed in them, it may be presumed that their base was a baselevel plane of erosion. The uplift which terminated cycle No. 3 was comparatively rapid so that the streams, quickly cutting down to the new baselevel, meandered on a gradually widening flood-plain, and, undermining the valley sides, produced the present bluffs. The preceding system of valleys—the broad basins of cycle No. 3—had no bluffs, although excavated into the same formation. While this cycle was undoubtedly several times as long as that which succeeded it, the strong contrast in the topographic forms produced is explainable under the supposition that the uplift during cycle No. 3 was slow and extended through practically the

entire period, while the uplift of cycle No. 4 was rapid and soon terminated. so that during the greater portion of the period the earth movement was quiescent. The cañon-like characteristic of the erosion product of cycle No. 4 is an important point to be remembered, as it will be of great value in correlating the different baselevels in different districts of the upper Mississippi basin.

The position of the sea coast at the close of cycle No. 4 is unknown, but I will anticipate future studies sufficiently to consider an extension of its drainage system to a distance at least twice as great as formerly, and, in determining the altitude of the district at that time, will add, besides the 100 feet for the depth of the valley at Freeport, 300 feet on account of the increased length of the streams.* In this way we obtain a maximum altitude for the "mounds" of 941 feet, and an altitude for the baselevel in the Pecatonica valley of 466 feet. The present altitude of baselevel No. 4 at Freeport is 720 feet, and, as the present water level is not materially different from its position at the close of cycle No. 4, it may be urged that our estimated altitudes are very much too low. But the streams of the Mississippi basin are not on a perfect baselevel of erosion. They are depositing extensive alluvial plains, and so are the streams of the central Ozarks which are far above a baselevel. Our streams are capable of eroding at a greater depth than their flood-plains, and I consider the whole country above the head of the embayment region to be above a true erosion baselevel. So I do not think that 456 feet is *much* too low an estimate of the altitude of baselevel No. 4 in the Pecatonica valley at the end of the fourth cycle.

Baselevel No. 5. This last of the preglacial cycles of erosion in our district was instituted by a renewed uplift and a revival of energy in the streams, which quickly trenched new valleys or cañons in the bottom of the former system. An abundant water supply being secured from glacial gravels in the valleys, there is little inducement to send down wells to the rock-floor of the cañons. Consequently, we know but little more about them than their existence, and also that they are usually bounded by slopes and rarely by perpendicular bluffs. In the few places where these slopes have been determined by studying them in relation to the depth it would seem that the

valleys are very narrow at the base. Indeed, there is no evidence that the streams had trenched their new cañons to the new baselevel before the close of the cycle.

The depth of the lower cañons in the Pecatonica valley is probably not less than 200 feet. If we may judge from the imperfect data at hand, these valleys increased in depth toward the northeast. This seems to indicate a general tilting of the district toward the southwest. As this district is but a small portion of a great geologic province, we may presume that this tilting was extended over a much larger area. May it not have proceeded from some point far northeast of our district, as, for instance, the Laurentian area of uplift? May it not have been a portion of the temporary uplift of the northeastern part of North America, to which the inauguration of glacial conditions is by some considered to have been due?

The altitude of northwestern Illinois at the close of erosion cycle No. 5 is undeterminable at the present time. It is assumed that the sea coast was even farther distant than during the preceding cycle. An addition of 500 feet to our last estimate, or a maximum altitude of 1,441 feet, is probably not too much. The general upland surface would then be 1.200 feet above the sea, and the water level about 900 feet. This would not be sufficient to bring on glacial conditions in our district, but it is assumed that the presence of an ice-sheet in northwestern Illinois was due to introduction from a more elevated area to the northeast.

Type Section.

The conclusions expressed in the preceding pages may be summarized into the accompanying ideal section (figure 1), designed to illustrate the ancient baselevels developed in the vicinity of the city of Freeport. It will serve an important purpose in the matter of reference, and may be known as the Freeport baselevel section. It is exaggerated vertically, but is true to the impression which an examination of the topography of the area would make on the average student.

A subject of considerable interest is the relative length of the several cycles of erosion here indicated. The solution of this problem is dependent on too many factors of unknown quality to give any present estimates much value. It is nec-

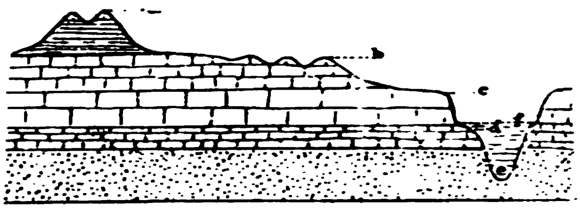


FIG. 1. IDEAL SECTION ACROSS A PORTION OF THE PECATONICA BASIN NEAR FREEPORT, ILL.
a. Peneplain No. 1. b. Peneplain No. 2. c. Peneplain No. 3. d. Baselevel No. 4. e. Baselevel No. 5. f. Present valley bottom.

cessary to know (*a*) whether the several uplifts were slow or rapid and whether they occupied the entire cycle or only a small portion of it; (*b*) the amount of average annual rainfall in the district during the several periods; (*c*) the state of the vegetation and the climate; (*d*) the lines of drainage; (*e*) the resistant properties of the several formations eroded, etc. Ignoring all the factors excepting the amount of material removed and the evidences of age presented by the different topographic forms, the writer would consider the relative lengths of the several cycles about as follows: Representing the last cycle by 1, the upper cañon valleys would require 5, and the basins constituting the so-called peneplain No. 3 the figure 25, to indicate the ratio between them. Cycle No. 2, ending in the completion of peneplain No. 2, might be represented by 200; and the first and probably most important cycle, that which resulted in the formation of the supposed peneplain of the summit of the "mounds," might require a figure exceeding 500. It is needless to add that these figures are mere guesses, liable to modification at any time.

CORRELATION.

It is not proposed to definitely correlate the baselevels of northwestern Illinois with the series developed and studied in other distant districts. Such correlation can be effected by direct tracing from one district to another, but in the Mississippi basin a difficulty is encountered in the following facts: (*a*) the several baselevels are so close in vertical distance that a very thorough study is required to distinguish them; (*b*) in passing away from the centers of uplift, the various

baselevels approach and at times merge into each other;* and (c) a large portion of the province has been glaciated so as to obscure the preglacial topography. But a few suggestions, as to what correlations are probable and apparently supported by present data, will not be out of place.

During the past summer, Dr. H. B. Kümmel, after a short study of the geomorphology of a portion of the Driftless Area in Lafayette and Grant counties, Wisconsin (immediately adjoining our district on the north), published his conclusions about as follows:† He recognizes a peneplain consisting of a "broad undulating upland, with an elevation of from 850 to 1,000 feet;" a few "monadnocks rising above it" and culminating in the Platte mounds, 1,250 to 1,300 feet above the sea; and a system of comparatively deep narrow valleys, trenched below the peneplain. These valleys, because of their being bounded by steep bluffs, surmounted by gentle slopes, he considers as the product of two cycles of erosion. "The process by which the valleys are being formed is not a direct continuation of the process by which the gentle upland slopes were fashioned. The valleys were cut in the upland surface after it was elevated from the low position which it had during its formation." In these adjoining districts belonging to the same area of "uplift," the correlation of the several baselevel planes is easy and definite. Dr. Kümmel's peneplain is a continuation (without further uplift) of peneplain No. 2 in the more southern district. The Platte mounds belong to the same series as the monadnocks in Illinois. The gentle upper slopes of the valleys are equivalent to peneplain No. 3 in the Pecatonica basin; and the narrow bluff-bound cañons are an undoubted continuation of the similar valleys in Illinois.

The Cretaceous peneplain has been recognized in southern Arkansas by Mr. L. S. Griswold.‡ It emerges from under the Cretaceous formations as a gradually rising plain. "At a

*This idea was first suggested to the writer by Mr. M. R. Campbell, who, in conjunction with C. W. Hayes, after a complete study of the geomorphology of the southern Appalachians, has traced the Cretaceous peneplain in Tennessee and Kentucky, near the Ohio river, to a position only 200 feet above the Tertiary peneplain. They think it probable that the Cretaceous peneplain merges into the Tertiary over a portion of the upper Mississippi and Ohio basins.

†Science, June 28, 1895, pp. 714-716.

‡Proceedings of the Boston Society of Natural History, vol. XXVI, author's edition, May 14, 1895.

distance of fifteen to twenty miles from the border, the plain as such is no longer seen, but we have the projected position of the plain surface indicated by the uniformity in the elevation of the crest lines of the ridges." Unless some remarkable axis of deformation occupies the position of the Arkansas valley, this same peneplain is represented by the Boston mountains at an elevation of 2,000 feet above the sea. Thence it gradually slopes to the north, and in south central Missouri passes across the higher upland surface at an altitude varying between 1,350 and 1,500 feet. The Ozark plateau bears the same relation to the mountain system of central Arkansas as the Cumberland and Alleghany plateaus do to the Appalachians. From the valley of White river in southern Missouri to the so-called "crest" of the Ozarks, the general upland surface is nearly level, but descends very slightly to the north against the prevailing direction of drainage.

Beyond the "crest" the upland slopes rather rapidly toward the Missouri river; and there the Cretaceous peneplain has probably been largely destroyed. This is apparently true also on the eastern slope of the Ozark uplift. But from the axis of deformation of the Cretaceous peneplain to the Missouri, the two baselevel planes—elsewhere designated as Cretaceous and Tertiary—have been gradually converging and probably merge into each other along some line in northern Missouri. The upper peneplain being entirely destroyed throughout a large area surrounding the district in which they merge, the truth of this proposition can only be determined by the discovery of Cretaceous strata within this district near the same level at which the Tertiary peneplain appears. For the above reason, also, it is very difficult to locate the Cretaceous peneplain in northwestern Illinois by direct tracing alone. We may follow one peneplain down to the level of a later one, on one side of the "merging" area; but we cannot say, with full confidence, that the peneplain which rises on the other side is strictly contemporaneous with it.

Hayes and Campbell* have definitely located the Cretaceous peneplain in the southern Appalachians, and, tracing it westward across the Cumberland plateau, they find it represented

*Geomorphology of the Southern Appalachians, National Geographic Magazine, vol. VI, pp. 63 126.

by isolated outliers of the latter in central Tennessee and Kentucky, at levels which would bring it down to about 1,000 feet above the sea at Louisville, Kentucky, or only 200 feet higher than the Tertiary peneplain at the same place. It is evident that the central Mississippi basin is an area of depression. The Illinois coal basin has been an area inclined to depression, while contiguous districts were being uplifted, since the early part of the Silurian period; and an examination of good topographic maps will bring to light the fact that central and southern Illinois are now depressed somewhat below the surrounding areas of so-called structural "uplift," causing its upland surface to be apparently continuous with that of the lower Mississippi region without any marked deformation along the line of junction. Consequently it is not improbable that, over a very large portion of the Illinois depression, the plane of the Cretaceous peneplain does not materially differ from the baselevel plane of the Tertiary era.*

Now the peneplain which is apparently represented by the summit level of the "mounds" of northwestern Illinois, southern Wisconsin, and eastern Iowa, descends toward the south at a rate which would take it below peneplain No. 2 on the southern side of the Rock river. As its elevation in our district was apparently due entirely to an uplift proceeding outward from some point in southern Wisconsin, we may assume that the coincidence between peneplains Nos. 1 and 2, in central Illinois, needs no further proof. In this connection it may be interesting to learn that Leverett and Salisbury have found sands and gravels apparently *in situ* in Adams and Hancock counties, Illinois, which they are inclined to regard as a Cretaceous formation on account of the large numbers of sharks' teeth and other fossils of a Cretaceous facies which occur in the drift of that vicinity.

Considering all the evidence in its proper bearings, it would appear that the Cretaceous peneplain, descending to the level of the Tertiary peneplain on the southern side of the Illinois depression, again rises above it on the southern slope of the Wisconsin uplift as peneplain No. 1 of the Freeport section, represented by the summit plane of the monadnocks of the district.

*This hypothesis was first suggested to the writer in correspondence with Mr. Frank Leverett.

To completely demonstrate the age of peneplain No. 1, it will be necessary to trace it westward to the edge of the Cretaceous strata in northern Iowa. But it has been mainly destroyed west of the plateau bounded by the "Niagara escarpment" in northeastern Iowa, and the country is so heavily drift-covered that the preglacial topography is somewhat obscure. Close to the village of Rockville, in Delaware county, McGee describes* a conglomerate formation resting on the Niagara limestone and overlain by drift, and he correlates it, largely on lithologic evidence, with certain Cretaceous outliers in southeastern Minnesota. After considering the evidence, he says: "On the whole it is safe to provisionally refer the Rockville conglomerate to the Cretaceous, and to more doubtfully correlate it with the Nishnabotany sandstone of southwestern Iowa, and (at least approximately) with the Fort Dodge gypsum of western central Iowa." Unfortunately, it has as yet yielded no fossils, so that its Cretaceous age is not positively proven. However, if it is a marine formation, its high position precludes the probability of its being a Carboniferous or Devonian outlier; and the absence, so far as known, of a Tertiary sea in Iowa would seem to support its Cretaceous age. In regard to its position, McGee further says: "It crowns one of the salients separated by the narrow gorge of the North Maquoketa from the Niagara upland which extends thence nearly to the Mississippi river." Its altitude is too great for peneplain No. 2, but it appears to bear such a relation to peneplain No. 1 that they may be correlated with each other in a general way.

In southeastern Minnesota undoubted marine Cretaceous deposits occur at levels varying between the 1,000 and 1,150 foot levels. This is in a district not very distant from the area occupied by the "mounds," and unless there has been a very great uplift of the Cretaceous baselevel in the district adjoining, on the southeast, that in which these Cretaceous outliers are found, we may expect to find this peneplain over the Driftless Area,—if any remnants of it exist,—at about the level of the summit plane of the "mounds." In short, all the evidence, although fragmentary, seems to lead us to the following conclusions: (*a*) if there is a baselevel plain of ero-

*Eleventh Annual Report, U. S. Geological Survey, Part I, p. 304.

sion, of Cretaceous age, traceable over the southern end of the Driftless Area, it is probably not elevated much if any above the summit plane of the "mounds;" (*b*) this summit plane appears to represent an uplifted and eroded peneplain; (*c*) this peneplain answers all the conditions of a nearly destroyed Cretaceous peneplain. In the absence of evidence to the contrary we will therefore provisionally correlate peneplain No. 1 of the Freeport section with the widely extended Cretaceous peneplain of the Appalachian and Ozark regions.

In working out the correlation of peneplain No. 2 we are confronted with one important fact, namely, that baselevels Nos. 2 and 3 approach and perhaps merge into each other throughout a large portion of the central Mississippi basin. Moreover, as the No. 2 peneplain has been largely destroyed around the eastern and southern borders of our district, it is difficult to say with certainty on which peneplain we stand when on an upland surface in the country south of Rock river. It is believed, however, that peneplain No. 2 is represented by all the higher rock surfaces throughout central and southern Illinois at an average altitude of about 700 feet above the sea. This upland surface, if continued into northeastern Missouri, rises to between 800 and 900 feet above the sea level. It is apparently the same plane which passes across the Meramec highlands west of St. Louis; and, unless I mistake, it penetrates the Ozarks in long, narrow basins, which in the central portions of the plateau attain an altitude of 1,000 and 1,100 feet above the sea. It is there overlain by an ancient river deposit whose lithologic resemblance to the Lafayette formation, as developed at the inner border of the coastal plain, is very striking.*

Hayes and Campbell recognize the Tertiary peneplain in western central Kentucky at an altitude of about 800 feet above the sea. At an equal distance north of the Ohio river, in southern Indiana, the general upland surface has about the same altitude. This Indiana upland plain is apparently continuous, through central Illinois, with peneplain No. 2 of the Freeport section.

Our conclusions as to the age of peneplain No. 2 in northwestern Illinois are as follows: (*a*) the presence on the pene-

*American Geologist, vol. xvi, December, 1895.

plain of residua of considerable size but composed of no specially resistant strata, and the comparatively small amount of subsequent erosion, make it evident that its age is not Cretaceous or earlier; (*b*) the amount of erosion accomplished in the district subsequent to the uplift of baselevel No. 2, as compared with that of other districts in which the age of the peneplains and valleys has been determined, makes it equally evident that this peneplain is not so young as the Quaternary era, and that, consequently, it is a Tertiary peneplain; (*c*) from its apparent continuity across the central Mississippi basin to the undoubted Tertiary peneplain in Tennessee, it may be provisionally correlated with the latter.

The baselevel indicated by peneplain No. 3 of the Freeport section, although widely extended through the Driftless Area, is probably limited, as an important originator of topographic forms, to the vicinity of the "uplifts." This very imperfectly developed peneplain may also have been due to a local uplift of the upper Mississippi region. It was preliminary to the general uplift of the continent which instituted the Quaternary era, and I would class it as late Tertiary.

The correlation of the cañon-like valleys is the least difficult of all. They belong to a cycle which was characterized by the formation of bluffs. This peculiarity of the immediate valleys of the streams throughout the central Mississippi basin is one of the first features to attract the attention of the visitor. We may leave our district in the valley of the Mississippi and follow its bluffs (through the preglacial valleys around the new gorges at Rock Island and at Keokuk) down the river to the embayment region. The surface line of the bluffs makes no abrupt changes in hight, and there can be no question of the synchronism of all the valleys of this class in Illinois and contiguous states. At the head of the embayment region our cañon valleys pass under the Lafayette plane. Across southern Illinois we can trace the same system of valleys to the Ohio. On the southern side of this stream, in Kentucky, they are found to pass under the well established Tertiary peneplain. Hayes and Campbell find the Lafayette formation, around the borders of the southern Appalachian province, resting on the Tertiary peneplain. If our attempted correlation of baselevel No. 2 in northwestern Illinois with the

widely extended Tertiary peneplain of the Appalachian province be correct, the Lafayette plane would belong in the former district at the level of the higher upland ridges constituting peneplain No. 2. There would then intervene, between the Lafayette period and the time of cañon valley erosion, a considerable length of time represented by the excavation of the broad basins of northwestern Illinois. It is possible that erosion cycle No. 3 in our district is the time equivalent of the deposition of the Lafayette formation in more southern districts. It is also possible that its products in the southern Appalachian and Ozark provinces are topographic forms of so little importance that the existence of this as a distinct base-level of erosion has not yet been recognized. Because of the above doubts I would locate the Lafayette plane in northwestern Illinois as probably equivalent to peneplain No. 2, or possibly to No. 3. In either case the cañon valleys are post-Lafayette and may properly be classed as Quaternary in age.

The buried valleys constituting the product of cycle No. 5 are not indicated beyond this district except in a few widely separated localities. Mr. Frank Leverett, in securing well-sections along the Mississippi valley, encountered evidences of a buried rock-shelf.* He says: "In places a preglacial valley is found to carry shelves of considerable breadth, now concealed beneath the present valley bottom. Thus at Quincy and St. Louis a rock shelf extends entirely across the present bed of the Mississippi, with an altitude 60 feet or more above the deeper portion of the valley. * * * * It is probable that such shelves as these are remnants of an old valley floor. Their full breadth is not known, hence we cannot judge whether they are mere fringes on the border of the deep channel or are of such breadth as to greatly reduce the width of the deep channel.". While we cannot completely demonstrate the synchronism of these Mississippi rock-shelves and those in our district, the valleys which are trenched below their surface may be correlated in a general way; for it is evident that the termination of preglacial erosion was practically contemporaneous throughout the central Mississippi basin. The first effect of the advent of an ice-sheet in northwestern Illinois was to depress the area and cause a silting up of the valleys in some instances even above the present water-level.

*Journal of Geology, vol. III, Number 7, p. 762.

In the Pecatonica basin the buried portion of the valleys is filled mainly with a blue silt of glacial derivation. The various members of the Kansan drift sheet rest upon this "buried loess," demonstrating the pre-Kansan age of the lower gorges. Hence they may be considered to represent a separate epoch of the Pleistocene period.

Northeastern Illinois is a heavily drift-covered region, and has an average altitude considerably less than the northwestern portion of the state. Many of the streams are out of their preglacial courses; and the writer would not venture to trace the various baselevels of the Freeport section into that district. Peneplain No. 2 may be represented by the general rock surface in Boone, McHenry, DeKalb, and Kane counties, at an average altitude of 700 feet. This portion of the state is depressed below its normal altitude as the lingering effect of the weight of the last great ice-sheet which has melted from it in comparatively recent times.

This discussion has developed several important inferences. It is only quite recently that the hypothesis was seriously entertained that the Kansan drift and the Lafayette formation were contemporaneous in deposition. Because of its bearing on this question it is exceedingly important that the position of the Lafayette plane in the upper Mississippi basin be completely demonstrated; for, if the preceding correlations are correct, the Lafayette period and the Kansan epoch were separated by at least one and probably two epochs of marked erosion. The second inference is that the pre-Kansan portion of the Quaternary era was at least several times as long as the remainder of it, considering the era to have begun at the time of the culmination of the first post-Lafayette uplift in the coastal plain. The third inference is that practically the whole of the true valleys of the state of Illinois (excluding basins in the northwestern corner and new rock-gorges of post-Kansan age) are early Quaternary in age.

All the preceding correlations are provisional and intended more as suggestions than as definite facts. It is only quite recently that the writer made the mistake of comparing a series of supposed Tertiary valleys in northwestern Illinois with valleys of an apparently corresponding series in the Ozark plateau region of southern Missouri.* It now appears that

*See the American Geologist, vol. xvi, December, 1895.

the former are the result of a later cycle of erosion, and that the apparent equality in size is due to a difference in resistant properties of the rock formations excavated. The hard cherty Lower Carboniferous limestones of southern Missouri will resist the erosive power of the streams several times as well as will the rather soft Galena limestone. The habit of the latter to stand in perpendicular bluffs is deceptive, and to determine the true relation between their resistant properties they should be studied in contiguous areas.

Origin of Drainage Lines.

The problem of determining the origin of the preglacial courses of the streams in northwestern Illinois is too complex for the present paper. I will advance, without argument, a few propositions in regard to it.

When northwestern Illinois emerged from the sea near the close of the Paleozoic era, the drainage lines were consequent on the structure. By the close of cycle No. 1, a complete readjustment had been brought about, placing the divides in the position of the synclinal axes. During the second erosion cycle the streams, revived by an uplift, trenched valleys to the new baselevel, and cut away the divides, almost completing a perfect peneplain. At the close of this cycle the divides were still over the synclinal troughs, and the drainage systems corresponded in a general way with the present (the Mississippi river being a probable exception). During another revival of erosive energy, the basins constituting the so-called third peneplain were excavated. At the close of this cycle, the streams had cut down into the rock-bed of their channels. and had trenched new valleys, in some instances in meandering courses, but in the greater portion of our district comparatively straight. The Pecatonica valley from Freeport to its mouth is a good example of the latter class. This portion of the valley is thirty miles long, averages between one and two miles in width, and is so straight that a line drawn through it would scarcely touch a bluff. Its position seems to be controlled by a monoclinal axis, or possibly by a fault. All the smaller streams of the district endeavor to follow the axes of anticlinal folds as closely as possible. Moreover, as the basins persistently follow these same lines, this habit was acquired on peneplain No. 2 (Tertiary?).

The ancient Rock-Illinois river was probably the largest original stream in the area of the present state of Illinois. It obliquely crossed the Grand de Tour-La Salle axis of uplift, and perhaps persisted from the first cycle. It was the only stream of our district that did cross this axis, which is still a prominent divide; and it is the only important exception to the rule of anticlinal drainage lines. The streams have cut back across the axis, some on one side and some on the other, so that the watershed does not exactly coincide with the axis of uplift.

In conclusion, I wish to add a few suggestions in regard to the age of the Mississippi river along the western boundary of our district. It is probably a comparatively recent creation. The origin of its present general course cannot be earlier than the Tertiary era. If any stream comparable in size with the present Mississippi flowed south across or close to the district during pre-Cretaceous time, it must have been captured by the headwaters of smaller streams flowing into the Cretaceous sea a few score miles west of the present course; for the strong tilting of the peneplain along the coastal portion, requisite to give the necessary drainage gradient of a stream flowing into the head of the Mississippi embayment, would give the small coastal streams so great an advantage over the larger stream that they could not fail to cut back into its basin and to capture it in a short time. Moreover, the distribution of the Cretaceous deposits indicates an incursion of the Cretaceous sea from the west as far as to the Mississippi river in southeastern Minnesota and, perhaps, beyond to Adams and Hancock counties, Illinois. Undoubtedly the Cretaceous drainage of the upper Mississippi region was mainly westward.

I am, further, inclined to the opinion that the Mississippi river did not flow in its present course across the area occupied by the "mounds" until near the close of the Tertiary era. Had a stream so large as the present Mississippi baseleveled the district along the present course, it should have more completely destroyed peneplain No. 1 in its vicinity. The present river passes the chain of "mounds" in a gap scarcely half a dozen miles wide. Residuals are generally found away from the main lines of drainage. In fact, if peneplain No. 1 is Cretaceous in age, the preservation of any remnants of it in this

district is remarkable, and is explainable only on the supposition that they were far distant from the main lines of drainage. Those who are engaged in a special study of the Missouri region frequently express the opinion that the great elevation of the western half of the Mississippi basin was delayed until well on toward the end of the Tertiary era. The upper Mississippi may well have flowed in some other course during this cycle.

The comparative recency of the origin of the present Mississippi may further be inferred from the narrowness of the upper trough or basin of the age of baselevel No. 3 in the Freeport section. Very small creeks in the central portion of the district have eroded basins in Galena limestone which are rarely less than a mile in width. The Pecatonica river above Freeport excavated a basin three miles wide in the same formation. The ancient Rock-Illinois river, in crossing the Galena terrane, baseleveled an area at least several times as wide as the last. On this principle of valleys being proportional to the size of the streams, so large a river as the Mississippi (all other conditions being equal) should have completed a basin at the very least fifty miles wide. Instead, through a large portion of the stream's course, where it crosses the Galena terrane, the baselevel No. 3 is undistinguishable by means of the topographic forms. At Dubuque the valley is a cañon about one mile in width and 250 feet in depth, reaching nearly to the general upland surface. If the basin of erosion cycle No. 3 is at all represented here, it must be by a 100-foot slope at the top of the precipitous bluff on the east side of the river. Again, in tracing the upper trough or basin of Carroll creek to the Mississippi river, baselevel No. 3 is found well defined all the way; but it cannot be located, without a close study, in the neighboring cañon of the great river. In short, the weight of evidence tends to prove that no large stream occupied the position of the present Mississippi on the western border of our district during cycle No. 3. But the cañon valley is of the proper size for a large river (although it does seem to be rather narrow at places, as at Dubuque), and it may have been excavated by the Mississippi in its present size. This is a very complex subject and will require much

additional work before any definite conclusions can be established. However, we may infer from the present data, that at or near the close of the Tertiary era there was a radical rearrangement of the stream courses of this portion of the continent. The problem of the Tertiary lines of drainage in the upper Mississippi basin is one of great interest and it awaits only future researches for its solution.

NOTE ON THE FORMATION OF GOLD ORE.

By K. von Kraatz.* Translated by H. V. Winchell.

In spite of the many revelations made by gold mining in the last fifty years and in spite of the tremendous practical interests that are continually leading to new searches for the sources of gold, we are still but poorly informed as to the origin of this noble metal and the conditions governing its deposition. It is true the secondary occurrences in river sands and in the so-called placers (*Seifengebirge*) are explained without difficulty, although even here widely different theories are expressed on one point, viz., the explanation of the occurrence of nuggets and the supposed reënrichment of gold sands that have been already worked out. It will be readily admitted that large gold nuggets cannot be transported by the floating or rolling action of water; and most geologists have believed until recently that they are found too seldom in the solid quartz to account for those found in the alluvions. But since more careful observations, like those of Howitt in Australia, have been made upon the occurrence of nuggets embedded in rock† it is known that pieces are found in quartz (more widely scattered to be sure) of equal size with those of the secondary deposits; and hence the size of placer nuggets no longer compels us to accept the theory of solution and reprecipitation of the gold. We have, therefore, to deal with transportation of the larger masses and the supposed recharging with gold.

Now it is certainly not an unjustified assumption for us to conclude that the gold nuggets did not grow as we now find

*Zeitschrift für praktische Geologie, May, 1896. Extract from the Verhandlungen des Naturhist, Med. Vereins zu Heidelberg, N. F. V. Bd. 4 Heft. Carl Winter's Universitätsbuchhandlung in Heidelberg.

†The newly discovered gold fields of Coolgardie in southwestern Australia have also yielded a considerable number of nuggets.

them, but that together with the associated quartz they were rolled to their present positions in river beds. Enclosed in an equal bulk of lighter rock the transportation of the metal would be much more easily accomplished. As for the supposed reënrichment of washed-over gravels, this is only reported in districts like the Urals and the older California workings where the methods were crude and only perhaps 50 per cent. of the gold was saved originally. It would not be surprising if in such localities the gold particles, by reason of their high specific gravity, should again be collected at the same level by circulating waters, and thus (in the Urals after a period of about 25 years) make possible, with improved methods of working, another exploitation of the old ground. One fact, however, is worthy of note: small, well-formed, sharp-angled crystals of gold are frequently noticed, and for these the theory of formation in the places where they are found seems the most natural.

From the statements just made it is plain that we can by no means prove that gold cannot be dissolved and redeposited in secondary deposits. But I intended to suggest that although the theory of chemical formation may not be satisfactory for ordinary secondary deposits, yet the occurrence of large nuggets is susceptible of ready explanation. In primary deposits it is quite another matter. To what extent we are obliged to accept the theory of deposition from solution I will endeavor to show in the following paragraphs.

If we wish to acquire a correct apprehension of the conditions governing the deposition of gold we must, first of all, consider its paragenesis. Henry Louis has with great care described all the minerals with which gold is associated. Although their number is considerable, the number of those which can be looked upon as characteristic and universal associates of gold is quite limited.* Among these the most prevalent are quartz and the commonest sulphids, such as pyrite, chalcopyrite, galenite, zinc blende and stibnite. Of these latter, pyrite takes the first place by reason of its wide distribution and its constant presence where gold is found. We shall now endeavor to account for the common occurrence and

*"On the Mode of Occurrence of Gold," *Min. Mag.*. vol. x, No. 47, pp. 241-247. See also *Zeit. f. prakt. Geol.*, 1894, p. 329: 1895. p. 84.

the essentially genetic relationship of the mineral combination, gold, quartz and pyrite.

Since it is only in rare instances that we find gold enclosed in eruptive rocks,* and even then serious doubts are entertained as to its being an original constituent, we must examine into the natural solutions from which the metal may crystallize or be precipitated.

One solvent which universally contains gold is sea water. The gold content which Sonnstadt detected by various means is, however, only found qualitatively and in such minute quantity that solution in sea water cannot serve as a general explanation of the deposition of gold. We should also, in the light of the theory, expect to find gold as an original constituent of marine sediments, contrary to the actual facts. Nevertheless, it is quite conclusively demonstrated that gold may be separated from solutions in which it apparently occurs as a chlorid.

K. Johansson demonstrated in a paper "Om Ryssland malmtyllgångar och dess Berghantering," that the gold of the Uralitic veins at Beresowsk may be secondarily crystallized out of solution. He writes: "With quartz we find pyrite, which by oxidation becomes limonite; and as subordinate minerals we have copper sulphid, galenite, cerussite, pyromorphite, etc. The gold seems to be principally contained in the pyrite and limonite and amounts to as much as 200g per ton. The gold content becomes less as depth increases, a circumstance which indicates that it may be of secondary origin. The presence of chlorine-bearing pyromorphite among the gang minerals is also an evidence of secondary deposition. It is supposed that the gold was introduced into the vein in the form of chlorid, a supposition that is warranted by the high content of pyrite, since this mineral precipitates metallic gold from its chlorine solution, as may be readily shown by experiment.

In his experiments Johansson used a funnel whose stem was filled with quartz fragments which were covered over with

*The only instance of the kind with which I am familiar is described by Möricke. But he also mentions the association of the gold with pyrite and thinks that the former was originally native in liparite and later became attached to the pyrite. *Zeit. f. prakt. Geol.*, 1893, pp. 143, 144.

grains of pyrite. Solutions of different strengths from $\frac{1}{1000}$ to $\frac{1}{1000000}$ were filtered through the pyrite. The filtrate showed no trace of gold by the tin chloride test (purple of Cassius test).* At my request Dr. F. Stockhausen repeated Johansson's experiment, with a similar result. He also found that lead, copper and antimony sulphids precipitate metallic gold from a solution of sodium auro-chlorate. That Johansson's discovery of this method of the precipitation of gold from its chlorine solution has a direct bearing upon its occurrence in ores of various localities is suggested by its paragenesis with chlorine-bearing pyromorphite in Wales, with chloridic mimetite of Nevada and chloridic vanadinite at Berjosowsk. But however simple this explanation of the deposition of gold by pyritic precipitation from its chlorine solutions may be, it is not applicable to the majority of cases. For frequently the chloridic minerals are wanting, and moreover the gold content of the rocks does not always decrease rapidly in depth, but very often remains practically constant to considerable depths. Here then we are obliged to turn for an explanation to quartz, the invariable associate of gold.

Highly siliceous waters are found to-day in geysers and hot springs of North America. G. F. Becker investigated the hot springs of California with special reference to their content of dissolved metals. As described by him, the geysers of Steamboat Valley, Nevada, which are situated 11 km. northwesterly from Virginia City, at an altitude of 1,560 meters A. T., arise from a gray, coarse-grained, biotite hornblende granite which is penetrated by fissures and overlain by andesytes and basalts. One series of fissures is filled by boiling, feebly alkaline water that is sometimes thrown out in jets three or four feet high accompanied by a roaring noise. Another series of fissures which now exhale only steam with carbonic and sulphurous acids, has, like the first series, covered its walls with hyalite, chalcedony and crystalline quartz. In the siliceous sinter and decomposed granite are found sulphur, sulphates, iron oxides, cinnabar, manganese and traces of zinc, cobalt and nickel. In 403g of sinter the following were determined:†

*"Mündliche Mittheilung." by K. Johansson.

†Eighth An. Rep. U. S. Geol. Sur. 1889, pp. 985, 967; see also J. Roth, Chem. Geologie, Vol. III, p. 309.

Antimony and arsenic sulphids	78.0308g
Oxide of iron	3.5924
Galenite	0.0720
Cinnabar	0.0070
Gold	0.0034
Silver	0.0012

That the gold was undoubtedly deposited by the hot waters was shown by the fact that in 15 pounds of decomposed granite arsenic, antimony, lead and copper were detected, but no mercury or gold. In what form the gold was held in solution was not ascertained, and a physical condition is as likely as a chemical one.

The hot springs of Nevada are the last manifestations of an eruptive era that has not long since ceased. If we look around for eruptive rocks in the famous gold districts we find that the principal gold fields of California, Australia and South Africa are cut in all directions by dykes of eruptive rocks of the dioryte and diabase group. The inference is not far to seek, that gold was present in the siliceous waters which accompanied the eruption of these as well as other deep-seated or surface flows, and that it was precipitated in the adjacent rocks by the agency of sulphids which already existed there or were sublimed by the eruptions. This hypothesis seems to be in harmony with the geological relations of the better known gold districts.

In recent times the Witwatersrand has become familiar to us through the works of Schenk and Molengraaf and the thorough investigation of Schmeisser. In what follows I have for the most part made use of Schmeisser's description.

In South Africa we can distinguish two varieties of gold deposits: The gold-bearing quartz veins and the auriferous conglomerates. The quartz veins belong for the most part to the steeply folded Swazi formation which has been highly metamorphosed by eruptives. The characteristics of these veins in different districts may be summed up as follows: The quartz veins are principally genuine bedded veins. They are numerously cut by greenstone dykes, chiefly of dioryte, which are also sometimes found to have a course parallel to the veins. Besides gold, pyrite is almost always present, but has very often been largely altered into limonite and iron ocher. Some veins contain large amounts of gold at the ou t

set, but deteriorate rapidly in depth. As a result of the rotting of the pyrites, brown and black veins are common. One vein is rich in stibnite, which carries gold in the form of coarse lenticular grains. Where the antimony mineral is decayed the native gold is found embedded in the yellow antimony oxide. Occasionally the gold is found in the borders of intrusive dykes. The veins which occur in the granite (underlying the Swazi formation) decrease rapidly in gold content as depth increases, even though they may be very rich near the surface.

Auriferous conglomerates are characteristic of the Cape formation, which rests unconformably upon the Swazi beds. The conglomerate strata carry a variable quantity of gold. They consist essentially of quartz pebbles which are held together by a siliceous cement. The gold is found almost wholly between the pebbles. When it occurs in them it seems to have been squeezed into small crevices. The greenish gray matrix that binds the pebbles together shows macroscopically pyrite and small quartz fragments, with occasionally some chlorite. Gold is seldom visible to the unaided eye: but it is also a rare thing to see gold in the matrix under the microscope. Dr. Koch found that pyrite, magnetite, zircon, rutile, muscovite, chlorite, secondary quartz and gold constitute the cementing matrix. The pyrite is usually rolled or rounded and seldom occurs in the usual combinations, ∞ 02 (210), ∞ (210) 0 (100) or 0 (111). Dr. Koch determined and I can corroborate it, that the gold is always later than the pyrite and nearly always united with or completely grown around the latter. Since gold in small quantity is not always easily distinguished from the sulphids, a larger quantity of the so-called concentrates,* i. e. the pyrite liberated by the stamps, was examined. Under the microscope are seen numerous small crystals, which are partly recognizable as quartz and partly as small gold crystallites. If the pyrite be now digested for several hours in a very dilute solution of potassium cyanide the small metallic crystals disappear and in their places remain only small irregular shaped cavities. Since pyrite which contains no gold is not attacked, even by 24 hours of treatment with the same potassium cyanide solution, the micro-

*Furnished by Dr. Rössler of Frankfurt a. M.

scopic crystals seen on the surface of the pyrite must be gold. This method of treatment is the same as that which plays such an important role in the cyanide process as practiced in the Witwatersrand. The chemical examination thus leads to the same conclusion as the microscopical; the gold is deposited on the pyrite and is of later origin. Since pyrite precipitates gold quantitatively from almost all its solutions it is natural to reason as follows regarding the auriferous conglomerate: Beds of pebbles composed of quartz and small pyrites crystals were involved in percolating siliceous waters carrying gold in solution. The gold was precipitated by the pyrite and deposited upon it. The occurrence of gold in the absence of pyrite, which might have precipitated it, may be explained by assuming the presence of a small amount of easily soluble ferrous sulphate, which has also the power of precipitating gold from its solutions.†

The source of the auriferous solutions remains to be explained. It is well known that the advent of acid eruptives is always accompanied by silica-bearing waters which have in many cases extensively silicified the rocks through which they passed. That such solutions can carry metals is proven by the numerous contact veins and ore deposits with which we are familiar. And that they sometimes carry gold was shown above by reference to the gold content of geyser deposits.

Now the schist complex of the Swazi formation as well as the Cape formation is cut by numerous dykes which are sometimes 30 meters in thickness. A number of these dykes have been studied microscopically by Dr. Koch. He distinguished among them quartz hornblende dioryte, quartz diabase, quartz proterobase (three dykes), quartz enstatite or bronzite enstatite, olivine diabase, olivine norite and tholeite. Faults and overthrusts are not uncommon in the whole gold producing area.

It is certainly not by chance that rocks of the dioryte group occur in close relation with gold districts in regions far re-

*It should not be forgotten that gold occurs in quartz unassociated with pyrite. In that case we can only explain its presence by dilution of the original solution and precipitation of the gold. In most cases, however, pyrite was originally present, as is shown by the hexahedral cavities or by the brown stain on the quartz from which the pyrite has been removed by decomposition and solution.

moved from each other, and it is, on the other hand, altogether likely that it is this very class of rocks whose presence serves as the invariable associate and *raison d'etre* of gold deposits. In Australia Howitt in particular has shown the intimate connection between the auriferous quartz veins of Swift's creek and certain dioryte eruptives.* At that locality the auriferous quartz veins occur at the contact of dioryte and schists, and Howitt explains their formation as a phenomenon accompanying the dioryte eruption. Similar conditions obtain in the newly discovered gold fields of Coolgardie, near Perth, as I am informed by Dr. Chas. Chewings. The gold-bearing formation is fissured by numerous eruptive rocks, among which porphyry and dioryte dykes predominate, and practical experience has shown that richness in gold depends upon proximity to the eruptive masses. In the Urals, also, as I am told by Prof. Futterer, the presence of gold depends upon the occurrence of eruptive rocks and tectonic disturbances.

We may perhaps look upon the auriferous character of rocks which are associated with dioryte as analogous to the formation of tin ore deposits near granite areas.† It is to be expected that similar later acid eruptives will also be found to have been accompanied by auriferous solutions. In this category we may place the rocks of the andesyte and trachyte class of Dilln in Hungary and Guanaco in Chili. Here likewise the gold occurs in silicified belts of the rock or in cracks filled with quartz, and usually associated with pyrite. Gold does not appear to be genetically related with rocks which are much more basic than those of the dioryte group; but always with those more acid. Thus we find it occasionally associated with quartz trachytes and dacites.

Summarizing the above arguments we may find: Gold usually comes from the interior of the earth in acid solutions in company with acid eruptive rocks like dioryte. The form of the dissolved gold salt cannot be determined. In precipitating the gold from its solutions the sulphids, pyrite particularly, and to a subordinate degree copper, arsenic, lead and

*"The diorites and granites of Swift's Creek and their contact-zone with the auriferous deposits." Melbourne, 1879.

†Rosenbusch, Mikrosk- Physiogr. 3d Ed. Vol. II, p. 258; Vogt, Zeit. f. prakt, Geol. 1892, p. 479.

antimony sulphids, play the most important part. These conclusions are proven by the constant paragenesis of gold and quartz and the almost universal association of gold with pyrite and its products. That gold is also sometimes precipitated by organic substances is rendered probable by the occurrence of veins in the Transvaal whose bituminous portions are unusually rich in gold.

NOTES ON THE QUATERNARY GEOLOGY OF THE MATTAWA AND OTTAWA VALLEYS.

By F. B. TAYLOR, Fort Wayne, Ind.

Introductory. In the autumn of 1893 the writer made two excursions to North Bay on lake Nipissing, first in August with Dr. F. S. Pearce, of Philadelphia, and again in September alone. Two or three days were spent each time searching for old shore lines on the hills or in studying the lower beaches and their relation to the old outlet of the great lakes. The greater part of the time, however, was spent in searching for high beaches, and particularly in an effort to identify the highest. The observations made then were afterwards published in detail.*

In 1895 the month of October was spent chiefly in the vicinity of North Bay and in the Ottawa valley above the city of Ottawa. It is the particular object of the present paper to present the results of this later work. The observations are somewhat scattered, but when taken in connection with what has been done by others and with the writer's work of two years before it is believed that they will not be without value. The paper is presented in two parts, the first relating to the higher, older shore lines, and the second relating to the lower, newer lines, in part lacustrine and associated with the abandoned outlet and in part to those of the contemporary marine waters in the Ottawa valley.

I. SHORE LINES AT HIGH LEVELS.

North Bay. The Nelson and McEwen beaches on the hills five miles northeast of North Bay were described in the pre-

*Bull. Geol. Soc. Am., vol. 5, 1893. Contains map of old outlet and of higher beaches north of North Bay. Also AM. GEOL., vol. XIV, Nov., 1894, pp. 282-285, with map.

vious paper.* They are both strongly and clearly developed. Another, called the Thibeault beach, on the hill about two and half miles north of North Bay was also described. The part seen there was only a short fragment and on revisiting the place last season it was found to be a weak feature and not well developed. The lands along the slope to the westward are better cleared now and although they present a rather irregular surface of drift and are in a very exposed place the beach was barely distinguishable upon them. From this I am rather inclined to doubt the propriety of classing this beach as one of the greater beaches to be used in correlations with other more strongly developed parts elsewhere. It is too weak and poorly defined to be safely used for that purpose.

Going north from Thibeault's the road is mostly through the forest and no conspicuous evidence of submergence was noticed. Half a mile north of Thibeault's a short ridge in the woods resembles a spit at about 1,050 feet; but its origin is not certain. About four and a half miles from town Chippewa creek was crossed at about 990 feet. The high fresh cut bank showed sand mixed with white silt, but showed scarcely any evidences of stratification. Above this is a stretch of slightly rolling ground with sandy soil at about 1,100 feet. This substantially corresponds with the level of the McEwen beach at about 1,095 feet (corrected).† This tract gradually rises to an ill-defined low bluff at about 1,130 feet and is probably the Nelson beach. From this rise a level plain extends about a mile through a maple forest to the house of Mr. McKenzie on the west side of the road six miles from North Bay. The altitude at McKenzie's and for nearly a mile south is about

*See first paper mentioned in preceding footnote. The name "Nelson beach" was never intended to have the wide application given it in recent papers by Mr. Warren Upham, but was used merely as a locality-name for convenience. Being a well determined part of the "highest beach" in a situation where it cannot be attributed to small or locally restricted waters, it is plain that the Nelson beach is in reality merely a part of the Algonquin beach.

†In the previous papers the altitude of the station at North Bay was supposed to be 658 feet above mean tide. The C. P. R. profile, obtained afterwards through the courtesy of the Geological Survey of Canada, makes it 662 feet. This correction, by adding four feet, should be made for all the points in the earlier paper that were measured from North Bay station.

1,150 feet. East of the road is Chippewa lake and other little ponds five or ten feet lower. North of the lake is a network of narrow, crooked, steep-sided, stony ridges with marshy hollows enclosed, probably glacial forms. Mr. McCollen's house is on a partially cleared hill to the east which rises to over 1,200 feet. The soil is a stony till with some sand and plenty of bowlders. No evidence of wave-wash or still-water sedimentation was seen above about 1,130 feet. A mile farther north near the cabins of two Frenchmen west of the road an old bluff was found at about the same hight facing over a swamp which borders Duchesnay creek—probably another fragment of the Nelson or Algonquin beach.

Trout Creek. Two efforts were made in 1893 to reach the highest beach at Trout creek, about 28 miles south-southeast of North Bay. Both failed on account of rain. This season another attempt was made with better success. A thin snow covered the ground in the morning, but by noon had disappeared. On the face of a steep hill about a mile east of the station the Algonquin beach was found in a cleared field facing northwest over the valley. It appears here in the form of a series of lightly cut terraces or steps. Beginning in the woods below the field eight benches were distinguished at altitudes of about 1,150, 1,165, 1,170, 1,175, 1,185, 1,195, 1,205 and 1,215 feet above sea level. Some of them are low ridges with shallow depressions behind. Those at 1,175, 1,185 and 1.195 are best developed, the last one the best of the three. The upper one has a low bluff of bowldery clay three to four feet high at its back in the northern part of the field, but fades away on the slope to the south. This bluff rises gently to a low knob at the north and passes into the woods. Near the north side of the field where it is most distinct the waves made a deeper cut, producing a slight indentation of the bluff line, like a small amphitheater. The tough clay of the slope is thickly massed with bowlders. The front of the low bluff shows plainly that the clay has been washed out, leaving the stones bare. The terrace is 50 to 60 feet wide. The road south of the field crosses a small stream and a small deltoid flat about 15 feet lower than the upper bench. These terraces were followed through the woods toward the southwest where some of them are more strongly developed, and

the upper one was traced a short distance south of the road. The surface of the field above the upper bench shows no benches, but only a number of rain gulleys. From the top of the field, (at about 1,335 feet) the view over the valley showed that several hill tops two or three miles away formed a considerable protection againt the open sweep of waves from over lake Nipissing. A level terrace line could be seen between two of these hills apparently at the same level as the benches just described. Half a mile farther east the road ends on a hill top. From this point one looks down on a hilly landscape of forest and field, the latter strewn with many large bowlders. In the road on the hill top there is one 15 feet long, 12 feet wide and projecting 10 feet above the ground. The altitude is here about 1,405 feet. No sign of submergence was seen above the terraces described.

Two miles north of Trout creek on the Pawassan road this beach was found again at about 1,220 feet. The position here is more exposed and the beach is correspondingly stronger in its development. It is a great curved spit of gravel about 400 or 500 feet long. It is mostly on Mr. Weiler's land in the field which fills the corner southeast of the cross roads. In the next lot east a gravelly hill of drift rises about 25 feet above the top of the spit. From the top of this hill lake Nipissing can be seen plainly. The waves had torn away the north side of this hill, making a sharp cut at the water line and leaving a very steep slope above. From this the gravel and sand were carried toward the southwest into shallow water and built into a wide spit which curves slightly southward. The soil on the spit is remarkably light. It is composed of fine gravel and sand, with a light loess-like material, and is very soft under foot. The hill was evidently a small island at the time of the beach. A mile to the east in a more protected place the knobs of gneiss had apparently been washed bare of their thin coating of drift at about the same level. All the hill tops for several miles around were islands. Some of these extended two or three miles farther northward.

Callender (C. P. R.). From this place a drive was made out the Pawassan road to a hill some six miles south-southeast. For two or three miles, and up to about 250 feet above the station, the country surface is largely silt and silty clay

with more or less sand, all water-laid thinly over the rocks and the ground moraine. On the west point of a hill about two miles out is a faint terrace about 190 feet above the station or about 975 above sea level. Just northeast of this is a large kettle-hole 60 to 70 feet deep. The rolling stony drift at this place appeared to be part of a terminal moraine. Some of the hills seem to be mainly of drift. but some show bare ledges of gneiss, especially towards their tops. A wide huckleberry flat called the "Blue Sea," which was crossed at about 1,035 feet, is bounded by high hills and is evidently a shallow lake bed filled with sediments. From the east side of this a long hill rises quite steeply. Bare bosses of gneiss were reached at the top of the slope at about 1,290 feet. They were evidently rounded by glacial action, but were weathered so that no striæ were discoverable. The house and barn of Mr. Joseph Binet. half way up the hill and north of the road, are on a fairly well formed terrace at about 1.135 feet above sea level. Above this are two others at about 1,150 and 1,170 feet respectively, both more sharply cut. Above the upper one is a steep rocky ledge with talus top about 30 feet above. The water may have stood at that place, but no distinct terrace corresponding to it was observed at that level on the gentler slope a few rods to the southwest. The benches are cut into stony drift, which is composed of tough clay with many cobbles. The slope faces nearly northwest and on the steep hills opposite there appeared to be a zone of rock washed bare at about the same level. Although it is about 40 feet lower than the beach at Trout creek, it seems almost certain that this is the Algonquin beach. The ground and situation are favorable, but no trace of submergence was seen at a higher level.

Localities in the Ottawa Valley. Two trips were made in search of high shore lines from Mattawa. The first was up the west side of the Ottawa river to Les Erables. At one place north of the Antoine river a faint terrace with gravelly surface suggesting light wave wash was found at about 870 feet. Birch hill farther north holds a small lake high above the river. The north slope of the hill is a great mass of morainic material undoubtedly constituting a terminal. It is apparently this bank of drift which holds the small lake up. The composition of the moraine is well shown in exposures by

the road which descends northward through a steep ravine. It is stony, gravelly drift with considerable sand and much white silt. A quarter of a mile south of this lake the slope on the west was explored and a horizontal zone of bowlders apparently washed free of other materials was found at about 1.010 feet. From the top of the hill 50 feet higher the surrounding hills were seen to have a similar mark on their steeper slopes. No other littoral forms were seen and it is uncertain whether this feature is in reality a shore line.

The second trip was made from Mattawa to Hurdman's farm about 21 miles south. About three miles out and at an altitude of about 720 feet a ridge of gravel and cobbles was found running north and south and exposed over lower ground, both east and west. The southern part is level, but it drops off slightly towards its north end. This was not certainly identified as a beach, but may prove to be such on closer examination. At this level there is an undulating plain two or three miles wide and much of it is covered with a thin sheet of white silt with some clay. It is water-laid, and in some sections four to five feet deep was seen to be free of stones. It appeared generally to overlie stony drift, which outcrops at many places. In the drift itself the silt seemed to be the main fine ingredient mixed with the stones. It takes the place of clay largely in making up the ground moraine. The same character was frequently seen in other places in this region. As observed on this excursion, the upper limit of the water-laid silt appeared to be at about 800 feet. From Roscoe's, six miles out, the road to Hurdman's is over a very rough, rocky country, for the greater part consisting of bosses of gneiss with half buried ravines between. The drift covering is generally rather thin, and almost the whole stretch is thickly covered with bowlders. The average is a good size, a foot or more in diameter with many much larger, mostly angular and nearly all of varieties of gneiss or granite. Two terraces of fine sandy gravel were found at about 1,060 and 1,100 feet. Both were in a somewhat protected position in an east-west valley and covered with dense undergrowth. It is doubtful whether either is a beach. Nothing else suggesting submergence or a shore line was seen. Hurdman's house is about 1,320 feet above sea level while some of the knobs in the fields

near by rise to 1,400 feet or over. This is the top of the country and affords a grand view all around. One looks away east and south over the tops of many hills that rise almost to the same level, forming apparently an ancient peneplain. Between the hills are deep valleys often wide, holding many lakes and streams that flow eastward with moderate descent. Towards the northeast the hills of Quebec north of the Ottawa river were seen clearly.

At Deux Rivieres, 22 miles east of Mattawa, another effort was made to find high shore lines. Almost the whole distance of eight miles south to Stony hill was over what are locally called "the plains" but which proved to be a great area of kames. This kame deposit is composed almost entirely of yellow sand too coarse to be blown by the wind. Deux Rivieres has an altitude of 520 feet above sea level (C. P. R. profile) and the limit of the sands was not reached on Stony hill at an altitude of about 1,210 feet. Upon this slope of over 700 feet in something less than eight miles the deposit is spread in characteristic kame fashion. In some parts the knob-and-basin topography is well developed. Other parts are billowy and others more nearly a plain. There are also some high, rather irregular ridges. Some of the kettles are 50 to 75 feet deep. All that were seen were dry, but there are a few lakes in the larger basins. About six miles out the road passes in view of Green lake along its west side. This lake is perhaps half a mile long and nearly as wide and is approximately 450 feet above the station (970 feet above sea level). In the central and lower part of the area the stony ground moraine seldom protrudes through the sand. But towards the south in the higher part of the area stony drift surfaces are common. The sand appeared to thin out in that direction and occurs there in patches. At an altitude of about 1,130 feet a distinct terrace about 300 to 400 feet wide was found facing north or slightly west of north. This shelf sloped from back to front ten or twelve feet and had a few bowlders scattered over its surface. The bluff at its back is high but not steep. The bench was followed to the east, where it fades away on a steeper slope, but no certain evidence of wave work was found—nothing resembling a beach ridge nor a spit nor did the bluff seem quite like one cut by wave action. It is not quite certain that

this terrace is a beach although it so strongly resembles one. Above its level there is the same billowy surface of sand and close to the road at about 1,210 feet there is a small steep-sided kettle about 15 feet deep. The sand as seen on this road appeared to be gathered more densely along three east-west belts, one low down, say 650 to 700 feet, another at 900 to 1,000 along the north side of Green lake and apparently holding it up, and a third at the top of the hill, 1,100 to 1,200 feet. The middle one shows bowldery knobs that seem to mark it as a terminal moraine. About two miles southeast of Green lake is Windigo lake, said to be larger and at about the same altitude, and Windigo hill as high or higher than Stony hill. Their basins are probably of impervious drift or rock underlying the sand.

The area of the sand is said to have very definite limits on the east and west extending about two miles each way from the road. Southward it thins out, but is said to extend several miles beyond Stony hill.

Nearly opposite Deux Rivieres the deep narrow valley of the Maganasippi river opens through the high plateau of Quebec, and it seems probable that the glacial drainage that formed the kame deposit was in some way related to that valley. The relation here is much like that described by Prof. Fairchild between the large kame areas of western New York and the deep valleys which indent the south shore of lake Ontario.*

Somewhat similar sand formations, but not so extensive nor, so far as seen, reaching to so high a level, were found at Bissett 12 miles and at Mackey 25 milès farther east. The knob-and-basin structure is not quite so prominent at either of these places, but at both there is a great rolling sand deposit overlying the ground moraine. At Bissett it was followed up to an altitude of about 800 feet above tide and at Mackey up to about 600 feet. At McKinnie's farm on the hill south of Mackey the highest point reached was nearly 800 feet, but above 600 feet the surface is of stony, gravelly clay. No trace of shore lines or sedimentation was seen on the upper slopes. At neither of these places, however, were

* "Kame Areas in Western New York south of Irondequoit and Sodus Bays," by H. L. Fairchild, Jour. of Geol. vol. IV, No. 2, 1896.

hights above 1,000 feet reached. Just opposite Mackey the valley of the river Du Moine opens towards the north just as does the Maganasippi at Deux Rivieres. At Bissett there is no valley opening exactly opposite. A small one opens from the north a few miles below, but at neither of these places did the relation of the sand area to the opposite valley seem so plain as at Deux Rivieres.

Eastward from Deux Rivieres the railway passes by a back valley and rises to 827 feet at Aylen. This valley appears to have been swept bare of nearly everything but bowlders. Much the same appearance was presented by the region east of Mackey past Moor and Bass lakes where the railway again rises to about 700 feet. It is not improbable that these valleys were swept out by the outrushing waters of lake Algonquin when the ice front still blocked the course of the Ottawa which lies a few miles farther north. Perhaps the sand deposits at Bissett and Mackey were modified by the same cause. Perhaps they might otherwise have been typical kame areas like that at Deux Rivieres.

The new observations near North Bay and those at Trout creek and Callender (C. P. R.) accord closely with what had been done before in that region. There can be no doubt of the recent presence of wide waters at high levels over lake Nipissing and the headwaters of the Mattawa river. At the five places seen in the Ottawa valley, however. no clear and certain evidence of high level submergence was found, except, perhaps, the thin silts and clays overlying the drift south of Mattawa up to about 800 feet. This limit for such a deposit would seem to imply a contemporary water surface at a still higher level, and it is more than probable that for a comparatively brief period such an eastward extension actually existed.

As related elsewhere, the results attained during the preceding month on the north coast of lake Superior, showing that there were no straits northward to Hudson bay, seemed to leave little support for the marine hypothesis of the highest beach in the northern part of the lake basins unless that hypothesis could be shown to be strongly reinforced by evidences from the region to the east of North Bay. The observations in the Ottawa valley are too meager to be taken as

final. But so far as they go they not only add nothing to the marine hypothesis, but the presence of the Deux Rivieres kame deposit, which appears to have been the latest noticeable phase of deposition at that place, suggests rather the hypothesis of a glacier dam. The absence of silt or clay overlying the sand on the lower part of the slope proves that the latter was not long submerged beneath still water after it was uncovered by the retreating ice. The Mattawa and Ottawa valleys are troughs in the ancient peneplain of the region and they are comparatively narrow and deep. It is impossible to deny that if a great sheet of land ice moved over this region from the north or north-northeast, as the striæ indicate, there may have been a short period when the ice blocked the Ottawa valley by filling it up for some distance east of Deux Rivieres and resting its front against the southern highlands below that place. The valleys to the west and possibly also for a short distance north above Mattawa may have been temporarily open water. But this condition would last only a short time at most. Perhaps this supposition explains the absence of stronger shore lines and the general absence of still-water sediments at high levels north and east of Mattawa, and it may be that the faint, doubtful shore lines and the thin silts south of Mattawa are in reality the remains of such short-lived still waters. The great valley of the river Du Moine reaching far to the north offers an appropriate channel, both as to position and direction with reference to ice-motion, for a great lobe or tongue of ice that may have formed a dam below Deux Rivieres. About two miles east of Mackey striæ were found running S. 20° and 25° W. (mag.). A little north of Mattawa on the west side of the river they bear nearly south (the direction here was not measured by compass). One and a half miles northwest of North Bay fine specimens of striæ were found close to the railway track and the predominant direction of the stronger ones is about S. 18° W., with a few running 5° to 10° east of south. No striæ were seen at the other places named. It is perhaps a significant fact that the scoured valleys east of Deux Rivieres and Mackey are just where the front of the Du Moine glacier would be at one stage of its retreat. These ideas, however, are not offered as conclusions which can be clearly affirmed

on the facts now at hand, but merely as suggestions which are indicated by these facts and which may be profitably borne in mind in future investigations.

One other point deserves mention in this connection. From Huntsville to South river the Algonquin beach rises at the rate of nearly six feet per mile.* Then from South river to Trout creek it appears to be about level. But from Trout creek to Nelson's, five miles northeast of North Bay, the beach descends northward about 75 feet in 33 miles. The Callender (C. P. R.) observation also shows the same northward descent. If the fainter forms found in the Ottawa valley are accepted as continuations of this same shore line, as they may be, then they too show northward descent and apparently a slight eastward descent also. It might be thought that the northward descent from Trout creek to Nelson's is not in reality a measure of the deformation of the Algonquin plane, but that the beaches at the two places are not the same. This is of course a possibility. But at each locality, at South river, Trout creek, Callender (C. P. R.) and near North Bay in 1893 and again in 1895, the greatest care was taken to determine the upper limit of submergence and the result was clear and satisfactory in each case. Callender (C. P. R.) is about 18 miles east of a straight line drawn from Trout creek to Nelson's. The northward component of distance from Trout creek to Callender is about 21 miles and from Callender to Nelson's about 12 miles. The altitudes of the beaches are. 1,220 feet at Trout creek, 1,170 at Callender and 1,145 at Nelson's. Thus the northward descent from Trout creek to Callender is nearly two and a half feet per mile while that from Callender to Nelson's is a little over two feet per mile. This allows nothing for a possible east-west deformation affecting Callender.

The beaches at these three localities are so situated that it can hardly be supposed that one was made and abandoned before another was begun. And the clear definition of each as the highest shore line adds much strength to the supposition of their unity as one beach.

*Am. Geol., vol. xiv, Nov., 1894.

Wherever the hills were ascended in the region east and northeast of Georgian bay it became at once apparent that their even tops were the remains of an ancient peneplain. From the hills south of Callender (C. P. R.) Mt. Talon, 15 or 20 miles to the north and beyond the Mattawa valley, was seen rising high above the general plain as a fine monadnock. No other so prominent was noticed in this region. In the highlands south of the Mattawa the Algonquin beach marks a water level that entered the deep valleys between the hills and extended far into the interior. On the north side of the Mattawa not only is the beach depressed, but the peneplain seems to show a corresponding depression also. In short, the descent of the Algonquin beach northward from Trout creek appears to be due to deformation since the beach was made, and it seems probable, therefore, as previously stated,* that there are post-Algonquin faults between Trout creek, or rather between South river, or Sundridge and Nelson's. And this deformation appears to have been finished before the beginning of the Nipissing beach.

The upheavals which tilted and warped the plane of the Algonquin beach before the formation of the Nipissing beach have been called the Algonquin uplifts.† Whether these occurred after, or part of them during the making of the Algonquin beach is a very complex question, which is full of importance in its bearing on the lake history and the history of the Niagara gorge. There is much reason to believe that the Simcoe region, including the Trent valley outlet, was raised during the life of lake Algonquin and before the breaking of the ice dam in the Ottawa valley. Sharp warping occurs in the region east and northeast of Georgian bay, but it apparently dies out towards the southwest so that the St. Clair river and the south end of lake Huron were only slightly affected. If the Mattawa-Ottawa region was uplifted before the ice-dam broke it would follow that the surface of the lake in the region near the dam was not up to the level of the highest beaches at the time of the break, and hence that the whole lake was not lowered over 500 feet when the dam broke, as it must have been the case if that event occurred before all the uplifts. In

*Am. Jour. Sci. vol. XLIX, April 1895, footnote on page 258.

†The Inland Educator, Terre Houte, Ind., vol. 2, No. 4, p. 222, May 1896.

the latter case the surface of the lake must have fallen from its place at present lake level at Port Huron, Mich., in Saginaw bay, and at Two Rivers, Wis., to a level 500 feet lower or to within 80 feet of present sea level. Then there had to intervene time enough for about 500 feet of uplifts in the Mattawa-Ottawa region before the Nipissing beach could have begun to be formed. We cannot say positively that this was or was not the course of events. It is a possible alternative. But it seems much more likely, and it apparently agrees better with the Niagara gorge, to suppose that the major part of the Algonquin uplifts occurred during the life of lake Algonquin and hence before the breaking away of the ice dam in the Ottawa valley. In this case when the break came the level of the lake at North Bay was not very much above the pass and the fall to the pass and to the level of the Nipissing beach was not great. But we do not know whether the change was directly to the Nipissing beach, the uplifts ceasing then altogether, or whether there may not have been some slight uplifting at North Bay after the fall to the level of the pass.

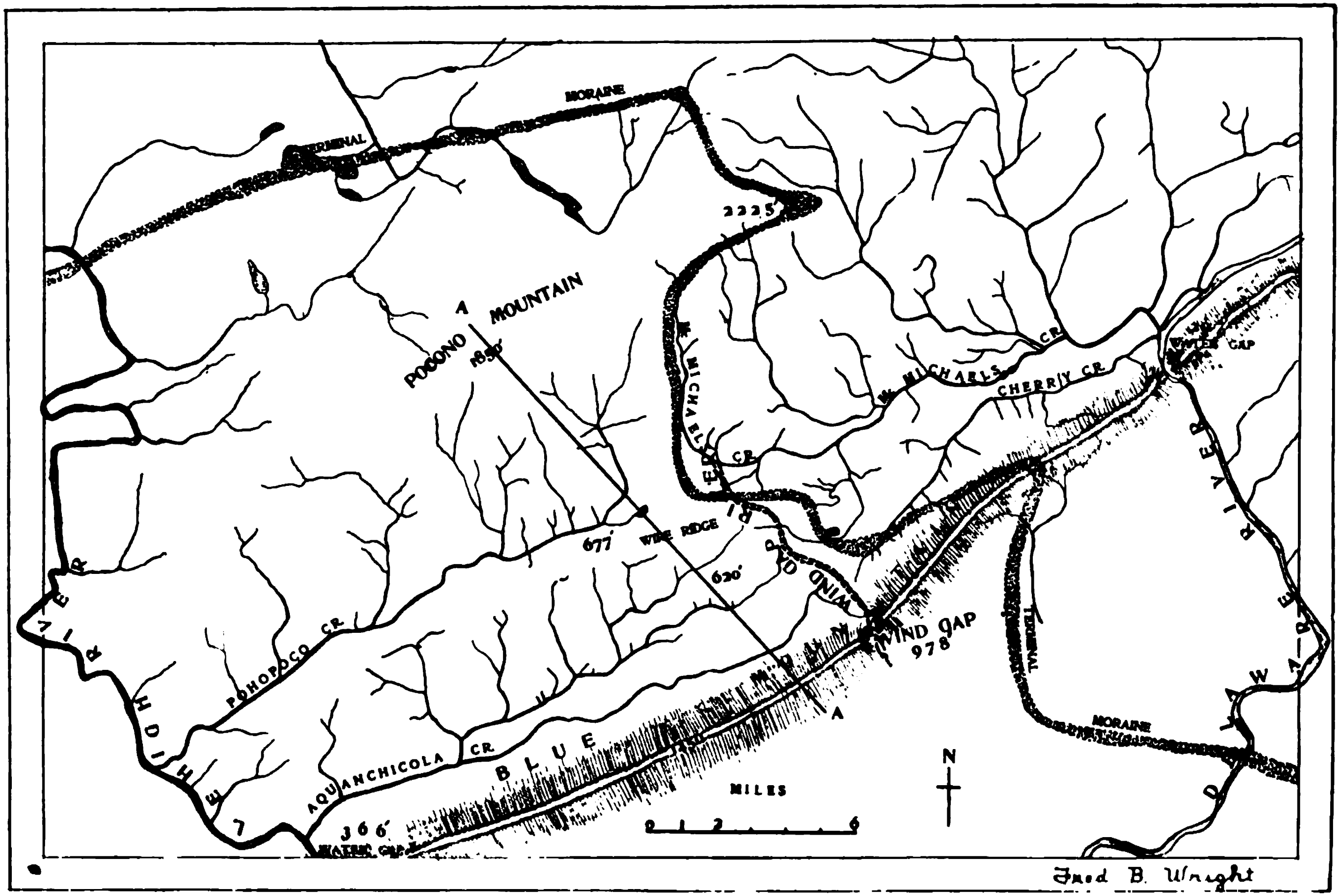
The whole subject of the Algonquin uplifts and their relations to the lake history is extremely complex. While a large number of data have been gathered which bear on the questions involved, probably many more will be needed before any decisive conclusion can be reached. But in justice to the subject and to those who have been most closely connected with its study it should be said that the data even now on hand have not yet been fully worked over. An account of submergence phenomena observed at lower levels in the Mattawa and Ottawa valleys will be given in another paper.

THE ORIGIN OF THE WIND GAP.

By Fred B. Wright, Oberlin, Ohio.

(Plate III.)

In the eastern part of Pennsylvania, on the boundary between Monroe and Northampton counties, the outcrop of Medina sandstone which forms, as elsewhere, the even crest of Blue or Kittatinny mountain, is cut by the Wind gap. Below the hard capping of sandstone lie the softer strata of Hudson River shales and Utica slates. Descending the northern slope of the mountain you pass from the Medina sandstone to the



MORAINE
TERMINAL
POCONO MOUNTAIN
A
1850'
2225'
677'
WIDE RIDGE
620'
WIND GAP
WIND GAP
978
LEHIGH RIVER
POHOPOCO CR.
AQUANCHICOLA CR.
BLUE MOUNTAIN
366'
WATER GAP
MICHAELS CR.
CHERRY CR.
DELAWARE RIVER
WATER GAP
MORAINE
TERMINAL
MILES
0 1 2 6
N
Fred B. Wright

THE WIND GAP.

Clinton shales and then to the Lower Helderberg limestone. Aquanchicola creek, flowing west, and Cherry creek, flowing east, follow along near the border between the limestone and the shale. North of the limestone you find the Oriskany sandstone, and then the Corniferous limestone, which, however, runs out before reaching the Lehigh river. South of the mountain you pass from the Medina and Oneida sandstones to the Hudson River shales and Utica slates.

"The summit level [of the Wind gap] at the center point of the bottom of the notch has an elevation of 978 ft. A. T. The crest of the mountain rises about 500 ft. higher. Measured at the crest line of the mountain the width of the gap is about three-fourths of a mile. The side slopes are beautifully rounded and curved downwards and pretty steep, so that the floor of the notch is about one-eighth of a mile wide."* The slope to the south of the gap is much steeper than that to the north. A little stream rises on the north slope of the mountain east of the Wind gap and flows westward to Aquanchicola creek; but no stream runs through the gap. Nevertheless the general appearance of the notch is such that one cannot help believing that at some time a stream ran over Blue mountain at this point and cut the gap. Also in excavating for a railroad through here they found, at a depth of twelve feet, waterworn pebbles, which indicate the former existence of a stream.† But, as it is quite probable that this gap furnished an outlet to the south for the water from the melting ice during the later part of the Glacial period, this may account for the waterworn pebbles. However, there seems to be no evidence that either the ice-sheet or changes of drainage caused by it had anything to do with the formation of the Wind gap. This cut must have been made long anterior to the Glacial period by some stream that flowed over the mountain at this place before the existing topography had been assumed, as is evident from the fact that there is no trace of the old channel north or south of the gap, and that the land slopes quite rapidly down on both sides from it. The present paper relates to the question, What has become of this river?

*Penn. Geol. Survey, G6, p. 63.
†Penn. Geol. Survey, G6, p. 63.

When the Lehigh and Delaware rivers were just beginning to cut their water gaps, probably a stream, smaller than either of them, was cutting down the Wind gap. But the Lehigh and Delaware rivers, being larger, had an advantage over the Wind Gap river in that they could lower their channels through the mountain more rapidly. When these two rivers had cut through the hard Medina sandstone and come into the softer Hudson River shales and Utica slates, they began lowering their beds at a greater rate; while the Wind Gap river was still slowly working away at the hard Medina sandstone. The relations of the outcrops of these formations are shown by figure 1.

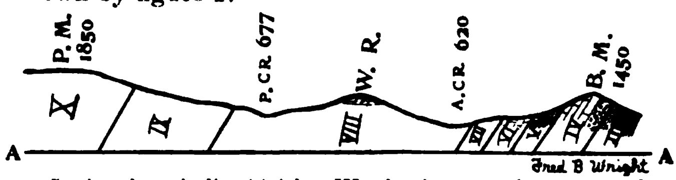


FIG. 1. Section along the line AA (plate III), showing successive outcrops of strata, numbered according to the Pennsylvania Geological Survey.

III, Hudson River shales and Utica slates. IV, Medina sandstone and Oneida conglomerate. V, Clinton red shale. VI, Lower Helderberg. VII, Cauda-galli grit and Oriskany sandstone. VIII, Chemung, Genesee, Hamilton, Marcellus shales and Corniferous limestone. IX, Catskill red sandstone. X, Pocono sandstone.

P. M., Pocono mountain. B. M., Blue mountain. W. R., Wire Ridge, capped by Catskill sandstone. P. Cr., Pohopoco creek. A. Cr., Aquanchicola creek.

The Lehigh and Delaware rivers, north of the Blue mountain, were at the baselevel of the bottoms of their gaps, as is shown by the broad valleys which extend down to the gaps and there suddenly contract only to widen out below. As the rivers lowered their beds at the gaps, the valleys of softer rock on the north would lower at nearly the same rate, thus giving increased activity to the tributaries which were cutting back toward the Wind Gap river. Since its bed was on a higher level, eventually the tributaries of either the Delaware or Lehigh tapped it and drew off all its water. Thus it can readily be seen how this gap was cut so long ago that there is now nothing left except the general form of the notch to tell of the former river.

Yet there are some other indications that point out the general course of the ancient river as it flowed from the north to the gap. McMichael's creek has its source at a distance of about twelve miles northwest from the Wind gap; it rises farther north than any of the tributaries of Pohopoco creek, which flows west into the Lehigh river; and it flows in a southerly direction toward the Wind gap for some six miles

and then turns suddenly east. Of course so much time has elapsed since the existence of this river that we should not look for many distinct signs of the old channel; yet we may expect some indications as to its former course in the stream which robbed the Wind gap of its water. That the upper portion of McMichael's creek is a part of the Wind Gap river seems quite probable, when you consider that this is the creek which would have had the best chance, among all the streams of this district, to cut back to the line of the old Wind gap drainage.

If, as is altogether probable, the relative sizes of the Lehigh and Delaware rivers and their tributaries have been approximately the same during their history, it is clear that the tributaries of the Delaware would cut back to the Wind gap river first, since it is larger than the Lehigh and also nearer to the Wind gap. Thus, although the difficulties of tracing the course of an abandoned preglacial stream in the glaciated region are very great, indications all seem to point to McMichael's creek as the thief which, long before the Ice age, robbed the Wind gap of its eroding stream. That the drainage has been somewhat changed by the glacial deposits must be admitted. But, with Blue mountain to the south, higher land to the north and the divide between the Lehigh and Delaware rivers to the west, there must have been, during the history of the Delaware, a preglacial stream flowing nearly in the present course of McMichael's creek.

EDITORIAL COMMENT.

Supposed Pre-Taconic Organisms.

The outlook for the detection of organic remains in Archean rocks is not encouraging. Since the passing of Eozoon, albeit with a vigorous kick, there seems to have been a panic among the spectral organisms of the crystallines. The Archean sponge described by Matthew turns out to be an effect of crystallization, other so-called fossils from the Canadian Archean seem to be largely subjective organisms, and now the radiolarians and sponges, the announcement of whose presence in the crystalline rocks of Brittany elicited wide-spread interest, after an analysis by Rauff are claimed to be (the ra-

diolarians probably and the sponge spicules at any rate) only mineral aggregates. So it has become evident that the determinations of the paleontologist in this field will no longer pass muster until reviewed by the petrographer.

Of another sort than these claimed and discredited evidences of life are the supposed annelid trails on the Huronian iron ores of Iron Mountain, Mich., recently described in *Science* by W. S. Gresley and the probable organic origin of some of which has received the endorsement of such excellent paleontologists as Dr. Walcott and Mr. Schuchert. The petrographer has not yet had his say in regard to these things, and though the rock specimens may show no structural characters which will serve to either affirm or deny the organic origin of these impressions, they will not be admitted as a demonstration of Archean life without a many-sided scrutiny; the more, as all other similar claims seem to be so rapidly crumbling, and since the Taconic and Archean ores occur in close proximity in the region mentioned.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Die Lamellibranchiaten des rheinischen Devon, mit Ausschluss der Aviculiden. By L. Beushausen. Pp. 1-514, pls. 1-38, 1895. (Abhandl. der Königl. Preuss. geolog. Landesanst., Heft 17.) While the author of this fine work was engaged, some twelve years ago, upon the investigation of the fauna of the Spiriferen-sandstein of the Hartz mountains, the paucity of knowledge of the lamellibranchs in the German Devonian, notwithstanding a wealth of material in collections, made itself so apparent that the influences of the land survey were directly thereafter interested to bring about a thorough study of these fossils. The scope of the work at first contemplated only the lamellibranchs of the lower Devonian, then, according to the author's prefatory statement, it was broadened to cover the species of the entire German Devonian and the work so divided that one part of it was assigned to Dr. F. Frech, the other groups to Beushausen. Frech's monograph, covering all the Aviculidae of these rocks, was published in 1891. That on the remaining groups became so extensive an undertaking that the author has felt the necessity of restricting it to the species of the Rhineland and Westphalia. The 315 species here dealt with are a sufficient evidence of this necessity.

One feature of this work is so distinctly novel as to invite remark. It contains no phylogenies, no family trees, no schemes of classification.

Let who will make these, here are the facts, says the preface and nothing is clearer throughout the contents of the book than that its writer is dealing precisely and cautiously with facts alone. Either the author has not, or believes he has not, found the key to nature's method of producing lamellibranchs. Some critics might say that here is a fine opportunity missed for excursions in these fields.

So significant are the results of this work to the large number of students of paleozoic faunas that a somewhat extended notice of them is justified. The paleontological part opens with the systematic description of species and genera.

Family Mytilidæ. *Modiola* Lamarck. The author considers the Devonian existence of this genus as proven, two described species possessing not only the typical form but also a small anterior adductor close beneath the beak, a curved, narrow, unthickened, toothless hinge and a linear marginal groove. It is possible that some of the American shells now referred to *Modiomorpha* will prove congeneric with these.

Family Modiolopsidæ. *Modiomorpha* Hall. The hinge structure of this genus is more fully elaborated than was done by Hall. The latter made out a single tooth in the left valve and a corresponding socket in the right valve. It is found that the left valve may have a tooth on either side of the median socket, one or both being absent on some species. Hall also made out the ligamental groove as external, but this is here stated to be a flattened surface so strongly striated as to suggest lateral teeth.

Nyassa, Hall. Though nothing new is added to the generic structure, the type species *N. arguta*, the common form of the genus from the Hamilton group of New York, is regarded a synonym for *Sanguinolaria* (*N.*) *dorsata* Goldfuss. To us, however, the specific difference seems well defined.

Dolabra, McCoy. This genus, referred with doubt to the aviculoids, still remains imperfectly known, no clue to the hinge structure being yet obtained.

Family Arcidæ. *Macrodus*, Lycett., (emended spelling). Without adding any new structural details, attention is called to the variation in size of the triangular ligament area, which is small in all these middle Devonian species but often becomes of greater extent in Carboniferous forms of the genus.

Family Nuculidæ. *Nucula*, Lamarck. Fifteen species of small, subtriangular, characteristically Devonian shells are described, and it is shown that Neumayr's genus *Myoplusia*, introduced for some of Barrande's "Nuculas" and based upon the presence of accessory muscular scars, is not to be distinguished in this respect from either *Nucula* or *Ctenodonta*.

Nuculana, Link. This name is preferred to the term *Leda*, Schum., more commonly employed but said to be preoccupied. The 7 species described show the arcoid teeth, median ligamental groove as in *Nucula*, the pallial sinus and the contracted outline peculiar to the genus.

Family Ctenodontidæ. *Ctenodonta*, Salter (*Tellinomya*, *Palæoneilo*, Hall). It is shown that while the shells described by Hall in 1847 as *Tellinomya* were not clearly defined as to hinge structure, the term *Ctenodonta*, which was better defined, must stand for species which have passed current under one or another of the three names mentioned and range from the Ordovician to the Trias. While finding no basis of generic distinction among these forms, Beushausen still recognizes the subgeneric value of *Palæoneilo* and certain other terms, thus *Ctenodonta* (restricted) includes species with a broad, shallow, obscure sinus directed toward the ventral margin: fine concentric sculpture. Type, *C. nasuta* Hall. *Palæoneilo*; sinus directed more posteriorly, stronger and making a distinct emargination of the posterior edge; fine concentric sculpture, often with strong concentric ribs. Type, *C. fecunda* Hall. *Koenenia* Beus.; the sinus sharply defined by radial ridges. Type, *C. lasii*, A. Roem. *Tancrediopsis*, nov.: anterior portion of shell larger than posterior. Type, *C. contracta*, Salter. *Prosoleptus*, nov.: shell highly inequilateral, abruptly narrowed in front, behind greatly widened. Type, *C. lineata* Goldf. All of these subgenera are represented in the 35 species here referred to *Ctenodonta*. The genus is somewhat less prolific in the American Devonian and is represented by only the first two and possibly the third of these subgenera.

Cucullella, McCoy. This term is preferred to *Nuculites* Conrad (older by 10 years), from an objection to the etymology of the latter. Such a reason rigorously enforced would throw out from nomenclature, to the general inconvenience, many useful and long established names. Among the synonyms of this genus is placed the term *Ditichia*, Sandberger, which was introduced for a small shell having two clavicles, one posterior. The author regards this a uniform occurrence in the young of *Cucullella*.

Ledopsis, Beus. Another nuculoid genus with subtriangular outline and two radial ridges, one anterior, one posterior departing from the beak. Though represented in the German Devonian it has not been recognized in American faunas.

Family Trigoniidæ. *Myophoria*, Bronn. The author follows Frech in referring to this genus the Devonian shells which writers generally have embraced under King's genus *Schizodus*. Without attempting to establish subgeneric differences, which in the opinion of the reviewer exist, the author includes his 16 species in four conventional groups, two of them suggested by Neumayr.

Family Astartidæ. *Cypricardella*, Hall. In the shells of this genus variously christened *Microdon*, *Eodon*, and *Microdonella*, the author notes the presence of a faint second tooth in both valves, and adds that these are for the most part faintly developed in Devonian species while in Carboniferous species they become very prominent.

Family Crassatellidæ. *Crassatellopsis*, nov. This genus is based pon the species *C. Hauchecornei*, from the Coblenz beds. The valves bear a distinct lunule in front of the beaks and the general aspect of the shell is that of Astarte. The left valve bears a strong tooth, the

right has a weak fore tooth and a strong hind tooth: there are no accessory teeth. The ligament is internal, lies on a thickened platform behind the teeth; pallial line entire.

Family Carditidæ. *Prosocoelus*, Keferstein. This is a genus known as yet only in the lower Devonian of the Hartz and the Rhineland. The shells are thick, often large, strongly convex and with a hinge strongly suggesting that of the recent *Venericardia*. The genus *Tripleura* Sandb., is regarded a synonym.

To the family Cardiniidæ is referred with doubt a new genus *Carydium*, represented by two species from the lower Devonian. These are characterized by a very remarkable hinge structure. The left valve possesses a thickened hinge-plate, bearing two strong submarginal grooves. The right valve has two ridges which fit into these grooves. Both grooves and ridges are crenulated.

Family Megalodontidæ. *Megalodus*, Sowerby. Of this peculiarly Devonian genus, the author makes out the structure of the hinge to be as follows: a central tooth; in the left valve a conical fore and a ridged hind lateral tooth, in the right valve a very strong fore, a weak and often wanting hind tooth and a ridged lateral tooth. But one species is described and that has commonly been known as *M. cucullatus*, but the earlier name *M. abbreviatus* Schloth is preferred; *M. adolfi* Clarke, from the Hartz is regarded a synonym.

Family Lucinidæ. *Paracyclas*, Hall. 7 species.

Family Cyprinidæ. *Cypricardinia*, Hall. 7 species.

Mecynodus, Keferstein. These shells, like *Goniophora* in exterior but with strongly developed hinge and lateral teeth, are not known in the New York Devonian, though Whiteaves has referred a Canadian shell thereto with doubt.

Goniophora, Phillips. The external resemblance to *Mecynodus* naturally induces an association with that genus notwithstanding what appear to be profound differences in the structure of the hinge. The author does not follow Hall in associating these shells with Modiomorpha but is disposed to regard them as cyprinids of degenerate hinge-structure.

Sphenotus, Hall. To this genus is referred a single species.

Family Solenopsidæ. *Solenopsis*, McCoy. Of this genus of elongate, tapering shells three species are described, one of them being identified with Whiteaves' *Modiomorpha attenuata*, from the Devonian of Manitoba. Except for this species the genus is not known in the American Devonian.

Family Solenidæ. *Palaeosolen*, Hall. These long ensiform shells, with subparallel margins and gaping anterior extremities, heretofore known only by the single American species *P. siliquoidea* Hall, are represented by 4 species.

Family Grammysiidæ. *Grammysia*, de Verneuil. This genus is much more closely restricted than it was by Hall, and is applied to shells showing more or less distinct evidence of the transverse cincture. Hall's diagnosis embraced many forms similar to those here referred to *Lepto-*

domus and *Allerisma*. Thirteen species are described, nearly all from the lower Devonian, a striking contrast to the American occurrence of such typical forms, which are almost exclusively from middle or upper Devonian faunas.

Allerisma, King (emended spelling). This still remains a somewhat unsatisfactory receptacle for species whose true relations will be better understood when the typical Permian species of the genus shall have been more fully investigated. With more abundant material the author must have more keenly appreciated the very slight interval between some of these shells, such as *A. münsteri* and *A. priscum* (which are embraced within Hall's conception of *Grammysia*), and the true Grammysias.

Leptodomus, McCoy. This was an ill-defined genus and it is not quite clear that the author's original intention is followed in referring to it shells of the type of *Grammysia constricta*, *G. communis* and *G. undata* Hall. The distinction between these many forms called *Grammysia*, *Allerisma* and *Leptodomus* is not particularly elucidated by the employment of diverse terms in preference to the practice of Hall to include all under the term *Grammysia*.

Pholadella, Hall. Represented by a single species, *P. peregrina*, from the lower Devonian.

Cardiomorpha, de Koninck. The author's conception of this genus would include within it again certain forms embraced in Hall's conception of *Grammysia*, such as those constituting his division *obsoleta*.

Edmondia, de Koninck. 1 sp.

Glossites, Hall. 1 sp.

Phthonia, Hall. 1 doubtful sp.

Family Solenomyidæ. *Janeia*, King. This heretofore little known genus is emended as to include shells having the aspect of recent *Solenomya* with narrow, extended anterior extremity, straight, toothless hinge and internal ligament. As present constituted it will cover many Devonian and later species whose generic traits lack distinctive emphasis.

Family Antipleuridæ. *Dualina*, Barr. A doubtful sp.

Silurina, Barr. 1 sp.

Family Cardiolidæ. *Præcardium*, Barr. It is claimed that, in accordance with Neumayr's observation, this genus is edentulate. There is a triangular area beneath the beaks, the inner margin of which is crenulated by the ends of radial ridgelets. The species are all upper Devonian as in New York, and the rare form, *P. vetustum*, Hall, is identified with Kayser's *Cardiola* (*P.*) *nehdenensis*.

Regina. Barr. The recognized difference between these forms and those which have been referred to *Puella* (*Panenka*) is in the prominence of certain of the radial ribs. There seems to be no evidence of hinge or of the subcardinal area characterizing most of the Cardiolidæ.

Puella (*Panenka*), Barr. 8 sp. Lower—lower upper Devonian.

Euthydesma, Hall. This is for the first time and with undoubted correctness placed with the palæoconchs. The only species is *E. Beyrichi* of the lower upper Devonian.

Tiaraconcha, Frech. (*Slava*, Barr.) The recognition of Frech's term proposed as a substitute for Barrande's much more euphonious name *Slava* is without justification. Only to a German is the name barbarous because of its tchechish origin. These are inflated shells, hingeless and with an obscurely defined cardinal area. The early parts of the shell are concentrically marked but in later growth a radial plication is assumed. 3 sp. middle and upper Devonian.

Buchiola, Barr. (*Glyptocardia*, Hall.) Here is a really first successful attempt to resolve the great mass of material everywhere known in the Devonian as *Cardiola retrostriata* into minor divisions or "species." The undertaking is a praiseworthy one as it helps to a better understanding of the relation of widely distributed variations of form. The author designates 17 species all adhering pretty closely to the type of *Cardiola retrostuata*, and these are distributed from the lower to the upper Devonian. It is not likely that this type in New York though abundant and having a similar range is susceptible of so narrow division. The hinge-structure has been unknown and the sentence "Inneres unbekannt" is still passed upon it. [The writer's preparations of Portage specimens of *B. speciosa* show a linear hinge-line which is somewhat elevated, and finely denticulate, the inner part apparently raised above the outer from which it is separated by a clear line, this line having the aspect of the margin of a very narrow subapical area]. *Opisthocœlus* nov., includes *Cardiola*-like species with sharply defined concave area behind the beak and a triangular ligament area. Lower upper-Devonian.

Cardiola, Broderip. This genus is left as a sort of catch-all for palæoconchs whose hinge structure is not understood. Nothing new is ascertained with reference to the structure of the type species. The 18 species here referred to the genus are certainly heterogeneous, as shown, if in no other way, by the affinity of some to certain New York intumescens-zone forms whose critical structure is known to render them quite distinct from *Cardiola*.

Lunulicardium, Münster. A great service toward bringing order out of the chaotic mass of species commonly referred to this genus has been rendered by the close restriction of this term. It may be objected that the writer here, as elsewhere at times, has not been sufficiently cautious about determining the characters of the genus from the type species and in the absence of a specified type from the first described species. The first species of *Lunulicardium* is *L. semistriatum*, pretty clearly defined and figured. Whether this is congeneric with Beushausen's conception is difficult to say. Münster seems to have erred in one direction, in referring to the broad posterior vertical flattening of the valve as a lunule, hence speaking of it as anterior, but Beushausen construes this a posterior ligament area and finds a true lunule on the other side of the beak. As now restricted the shells are subcircular, without dehiscence and radially plicate, and represented here by only a single species.

Chænocardiola, Holzapfel. This is one of the genera set off from *Lunulicardium*. It is emended by the author to include equivalve,

radially lined shells, without lunule, gaping in front, with beaks bent backward, the cliff being very long. The shells have the aspect of *Hemicardium* and were so termed by Barrande. Six species are described from the middle and upper Devonian.

Prochasma, nov. Another group of *Lunulicardium*-forms in which the outline is elongate, the anterior cleft in the valves transects the beak, is shorter and more oblique than in *Chænocardiola*. The surface of the valves is generally without radial ornament. The 10 species described are from the upper Devonian.

Family Conocardiidæ. *Conocardiopsis*, nov. Introduced for a single species (*C. lyelli* d'Arch. and de Vern. Middle Devonian) in which the posterior slope is carried out into a short open tube and, on the anterior slope the valves gape. It is regarded a passage form from *Lunulicardium* to *Conocardium*.

Conocardium, Bronn. 13 species.

In a chapter on the "Systematik" of these fossils, some interesting points are brought forward, those pertaining to the value of Neumayr's general divisions being suggestive. Neumayr proposed as one of his ordinal terms, Palæoconchæ, for a group of thin shelled, toothless species in which were included a number of families, the Cardiolidæ, Præcardiidæ, Lumulicardiidæ, Antipleuridæ, etc., etc. These shells are highly developed in the Silurian and lower Devonian faunas of the Bohemian basin and Neumayr's observations were largely derived from their occurrence there. They constitute a peculiarly interesting, if heterogeneous group and are all in need of closer study than their great delicacy of structure has yet permitted them to receive. They are abundantly represented in the lower upper Devonian of New York. Neumayr held this order to be primitive and the points of departure of those more highly differentiated. Numerous arguments have been brought forward against this view, the entire group being actually of comparatively late paleozoic age, undoubtedly occurring in some measure in the upper Ordovician of certain localities, but nevertheless remaining an emphatically Devonian association. The taxodonts are much more ancient and Jackson has demonstrated their primitive character from a study of the mode of development in these shells. Though it is now difficult to understand the precise relation of these "palæoconchs" to other recognized orders of the lamellibranchs, it would seem that the author more nearly approaches the truth in his suggestion that they are of an obstructed and reverted type. The name is here formally rejected, both on account of its being a misnomer and because of its incongruity as an ordinal term. In its place, to embrace three of its best known families, the Cardiolidæ, the Lunucardiidæ and the Conocardiidæ, is introduced the new ordinal term Cardioconchæ.

Two closing chapters of this work are entitled "The geological distribution of the bivalves in the Rhenish Devonian and their significance in stratigraphy," and "The relations of the bivalve fauna to the facies development of the Rhenish Devonian." In the latter chapter many interesting facts pertaining to bathymetric distribution are brought out. one of which is that the palæoconchs are largely if not exclusively deep sea forms. J. M. C.

CORRESPONDENCE.

NOTE ON A RECENT REVIEW ON TABULATE CORALS. The "review" of my recent work on the Alcyonarian (Tabulate) corals, that appears in the July number of the AMERICAN GEOLOGIST (p. 37), contains some suggestions that might be worthy of further discussion were they not accompanied by others which indicate that they are not scientifically intended. A reviewer may be pardoned for his inability, but this one pays disrespects to the veracity, not only of the author but also of those who approved his thesis. For example compare the following quotations: "The aim of my work consists, first of all, in establishing the significance of the characters that one observes in the Tabulata; to this end it has been necessary to study numerous species to the smallest detail, even by aid of thin sections prepared by myself; * * * * so far as possible I have investigated all facts anew from the specimens."

The above quotation is from the article reviewed; the following is the reviewer's statement: "Not only not performing investigations himself, but not even taking advantage of investigations already made, whether in the field of zoology or paleontology, he pursues a theoretic course independent of facts of supreme importance ready to his hand†." The review contains several such inaccuracies. It is of course not necessary to take further cognizance of them.

Mr. Girty is the author of some apparently very accurate investigations on the genus *Favosites*."‡ His publication was issued several weeks before my thesis on the corals was sent to press, but a copy of it came to hand too late for recognition. The facts therein presented would else have been eagerly added to my own results, since they supplemented mine perfectly. His theories, on the other hand, are directly opposed to mine on the subject of the relation of *Aulopora* to *Favosites*. It is, however, unkind in him to assert that my theories were formulated from other sources than from original investigation.

Minneapolis, July 22, 1896. F. W. SARDESON.

THE PLAINS PERMIAN. In his "Classification of the Upper Palæozoic Rocks of Central Kansas" (Journal of Geology, vol. III, nos. 6 and 7), Prof. Prosser applied the name Marion (first) to the "Marion flint and concretionary limestone," a member of the Chase formation, and (second) to the "Marion formation," a body of limestones, gypsums and shales outcropping above the Chase.

In my recent article, "The Permian System in Kansas" (Colorado College Studies, VI), I have pointed out the unity of the Marion formation with the lower or greater salt measures of Kansas and have applied to the formation, in this wider purview, the name Geuda. Under the

*"Der Zweck meiner Arbeit besteht in erster Linie darin die Bedeutung der Merkmale, die man bei dem Tabulaten beobachtet, festzustellen; hierzu war es nöthig, zahlreiche Arten bis ins kleinste Detail hinein, auch mit Hülfe selbstangefertigter Dünnschliffe zu studiren; * * * * soweit als möglich habe ich alle Angaben an Examplaren nachuntersucht. und dies war durchaus nöthig." Neues Jahrb. Beilageband X, p. 255, line 15.

†AMERICAN GEOLOGIST, vol. 18, p. 38, line 40.

‡AMERICAN GEOLOGIST, vol. XV, p. 131.

ological and other prejudices, which stood in the way of acceptance of the evidence of man's geologic antiquity, can scarcely be understood at the present time, though less than forty years have passed since those now forgotten controversies.

Having retired from business in 1872, Prestwich was appointed in 1874 as the successor of Prof. John Phillips in the professorship of geology at Oxford, where he taught until 1888. He was president of the Geological Society in 1870-72; vice-president of the Royal Society, 1870-71; and president of the International Congress of Geologists at its London session in September, 1888. On January 1st of the present year knighthood was conferred upon him by the Queen. The first volume of his text-book of geology was issued in 1886: and the second, containing an excellent geological map of Europe, in 1888. Three years later "he took up the defence of the rough flint implements found by Harrison on the chalk downs of Kent, a discovery almost as memorable as that of the implements in the gravels of the Somme." In other studies Prestwich wrote very fully of the "head" or "rubble drift" of England and Wales, France, and the Mediterranean region, as noted, with criticism, in the AMERICAN GEOLOGIST for April, 1894 (vol. XIII, pp. 275-279).

From a biographical sketch by Dr. Henry Woodward in the Geological Magazine for June, 1893, with a portrait, we learn that, since Prof. Prestwich's retirement from the Oxford chair, he has mostly resided at his country seat, Darent Hulme, Shoreham, Kent, a charming house built to his own taste some twenty-five or thirty years ago, full of quaint geological pictures, and even in its architecture illustrating geology at every turn. There he divided his time between his garden and his library, "always in association with Mrs. Prestwich, his ever-constant companion and most enthusiastic scientific friend, adviser, and co-worker." W. U.

VIEW IN THE RIO GRANDE VALLEY.

THE

AMERICAN GEOLOGIST.

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THE SO-CALLED SOCORRO TRIPOLI.

C. L. HERRICK, Granville, O.

(Plates IV and V.)

In several localities in the United States there are known beds of what is called tripoli or "American tripoli." Notable among these are deposits at Seneca, Newton county, in southwestern Missouri. According to O. H. Hovey* the Newton deposit is known to underly between eighty and one hundred acres, in an elliptical area, with a thickness of from ten to twenty-five feet. It is everywhere underlaid by stiff red clay, seams of which penetrate the tripoli in various directions. Attention is called to this bed because it, like the bed under consideration, is not a true tripoli, i. e., it is not an infusorial or diatomaceous earth, but of mechanical or chemical origin. It is also interesting on account of certain conflicting theories as to its origin. Thus Hovey concludes that the tripoli is derived from the flint or rather the chert of the country rock—a cherty lower Carboniferous limestone—by some process of decomposition which has left behind a very fine grained porous material. No details of the process of such decomposition have been suggested so far as known to the writer.

The tripoli has been analyzed by W. H. Seamon, now director of the School of Mines at Socorro, with the following results:

*Scientific American Suppl., June 28, 1894.

SiO_2	98.10	per cent.
Al_2O_3	0.24	" "
Fe_2O_3 and FeO	0.27	" "
CaO	0.184	" "
Na_2O	0.23	" "

The organic matter is not over .008%. Professor Seamon suggests a different origin for this substance, viz. that it is produced by the exhaustion of the so-called "tallow clays" of this region. These clays were described by professor Seamon in an article in the American Journal of Science of January, 1890, under the title "Zinciferous Clays of S. E. Missouri and a Theory as to the Growth of the Calamine of that Section." In connection with these beds Mr. Seamon has found decomposition products of a siliceous character greatly resembling the tripoli beds. The writer has been able to make a comparative microscopic examination of the various substances referred to through the kindness of director Seamon. The tripoli itself is a granular aggregate with the average grain less than .01 mm. in diameter, though there is an admixture of larger particles. The grains are irregular in form but are apparently crystalline rather than amorphous (in the absence of polariser this may be left an open question). A specimen of the decomposed chert, such as would be essentially identical with the tripoli upon the hypothesis advanced by Mr. Hovey, has a very different texture and seems to be a very unevenly sorted amorphous powder. While not denying that by a sorting under water this decomposed chert might give rise to beds like those in question, it yet is not easy to see how such deposits could occur under the conditions here prevailing.

On the other hand, a specimen of exhausted tallow clay taken from one of these beds, under the microscope, is almost indistinguishable from the tripoli. Passing now to the bed of so-called tripoli in Socorro county, New Mexico, we have a deposit of a very different nature and one for which we must apparently seek a very different origin. This deposit occurs on the east side of the Rio Grande, nearly opposite the town of San Antonio. The immediate valley of the river, varying in width from six to twelve miles, is filled with stratified fluvial deposits of sand, clay and gravel and the materials are, of course, such as may be derived from the adjacent forma-

tions. The greatly preponderating portion is of igneous rock, such as trachyte, rhyolite, andesite, basalt, etc. The hills on the east side of the river in this vicinity are, however, composed of stratified rocks of Carboniferous age, including some 600 to 700 feet of sandstone and dolomitic limestone with some interbedded gypsum and anhydride. At the foot of this exposure, and nearer the river, is an eruptive dyke not yet studied. There is everywhere evidence of volcanic displacement. On the western side of the river is a very interesting series of moniliform eruptions along a subordinate axis, giving rise to flows of andesite, trachyte, rhyolite and a great variety of contactual varieties, now being studied. Among these flows in the special region under discussion, there is a notable absence of the glassy and vescicular phases of vulcanism. There are no less than six craters or cores within a few miles of this locality, mostly of a distinctly acid nature, the most basic flow observed being an augite-andesite, and this only at the base of a trachyte core. Yet in only one instance have we encountered a glassy lava of the acid series. This obsidian is rather remarkable in itself and is of a creamy white color with few microscopic inclusions and remarkably free from microlites. It tends to be scoriacious and exhibits beautiful flowage structure. An analysis made by Mr. Leo Suppan of the Socorro School of Mines is as follows: (Number 146 Socorro series, south end of the Socorro mountains.)

SiO_2	72.052 per cent.
Al_2O_3	10.812 " "
MgO	1.124 " "
CaO	9.6 " "
Fe	Trace.
Alkalies	Not determined.

This occurrence and the high percentage of silica of the scoria is suggestive in explaining the "tripoli" deposit to which we now pass. This area is evidently a minor basin within the fluviatile sands. The depression cannot have been very extensive or deep and must have been at least temporarily connected with the river waters or a lagoon. The upper stratum in the adjoining terranes is a loose pebbly crag reposing on sand and clay beds of undoubted fluviatile origin. Within the basin, which may originally have been half a mile in diameter, the ordinary crag is replaced by a very peculiar

scoria-crag, from six to eight feet thick, but evidently thinest near the margins. The matrix of the crag is a sort of tuff with more or less concretionary aggregates of siliceous sand, but the bulk of the formation is composed of irregular fragments of scoria resembling pumice, varying in size from minute particles to fragments eight to ten inches in diameter. This scoria has been quarried and used for fire kindlers, for which purpose it is well adapted, as it will absorb a sufficient quantity of oil to kindle a coal fire easily. In some places the crag is chiefly composed simply of concretionary aggregates, composed of fine particles, evidently derived from the scoria by abrasion. Immediately below this scoria-crag is a layer of three to four feet of homogeneous, rather close-grained "tripoli," which has been worked to some extent as a polishing powder. It is white in color and under the microscope reveals small flakes of the concentric plates, similar to those formed by powdering the scoria. These plates and scales are of amorphous silica glass plainly derived from the scoria. That the composition of the scales differs from that of a typical acid obsidian seems to be clear from a comparison of analyses. The change must be due to a process of leaching which has increased the silica content. An analysis of the scoria made by Mr. S. J. Gormley, of the School of Mines of Socorro, is as follows:

SiO_2	91.206
Al_2O_3	1.022
Fe_2O_3	.6343
CaO	1.235
MgO	Trace.
Volatile	2.14
	97.741

An analysis of the "tripoli" immediately beneath the scoria-crag is as follows:

SiO_2	82.056
Al_2O_3	3.746
Fe_2O_3	3.24
CaO	.911
MgO	1.375
Volatile	6.42
	97.748

If our supposition is correct, that the "tripoli" is derived from the scoria, it is obvious that other materials have entered

into the former—such, no doubt, as form the earthy portions of the scoria-crag.

It may be noted that many samples of the scoria have minute microscopic crystals which polarize highly and have the optical properties of quartz and sanidin respectively, otherwise the siliceous lamellæ are isotropous in both "tripoli" and scoria.

Beneath the "tripoli" is a bed of yellowish sand, with irregular layers of tough reddish clay; still below this is a very fine grained stratum of yellowish "tripoli" which, while evidently less pure, is mechanically better suited to serve as a fine abrasive than the relatively coarse upper layer. Its composition, according to the analyses made by Mr. Gormley, is as follows:

SiO_2	79.416
Al_2O_3	1.391
Fe_2O_3	6.245
CaO	2.43
MgO	1.485
Volatile	6.06
	97.04

The silica content is here only a little higher than in some acid glasses, but the evidence shows that this composition is due to foreign admixture.

As to the method of formation we are shut up to a narrow range of possibilities. It may be assumed that a local basin, at a comparatively late period in the history of the valley and during an interval of subsidence of its waters, was filled by debris from a scoria bed. At this time the river erosion may have exposed and attacked such a flow as that first above described, and either transported the floating scoria to the relatively quiet eddy where they triturated each other until the tripoli was formed or else the debris of such triturated material was swept into the quiet retreat. In any event, with the filling of the basin the flotsam of scoria finally was stranded in the superficial layers forming the scoria-crag as we now find it. The extent of the beds has been but roughly estimated at from 300 to 400 feet in east and west diameter, and eight to ten times as great in north and south extension. A large portion has been eroded and washed away by periods of high water, although it is now far above reach of the river action.

The beds will ultimately have some economic importance as abrandants or filters. Probably by grinding between burrs and sorting by a cetrifugal a good quantity of polishing powder could be obtained, though lacking in the "tooth" of genuine "tripoli." For filtration and absorbents the material is admirably suited. The relative freedom from iron and impurities is a very important element.

Geologically the occurrence is especially interesting, as the material in this form seems to be unique.

For specimens and information respecting these beds the writer is indebted to Mr. Geo. H. Thwaites of Socorro, and for laboratory facilities and the included analyses to professor W. A Seamon, director of the New Mexican school of mines.

EXPLANATION OF PLATES IV AND V.

PLATE IV. General view in the Rio Grande valley looking north. The "tripoli" beds in the foreground. Three ranges appear in the distance on the opposite or west side of the river. They are the following, passing from left to right: The Socorro mountains, the Limitar range, the Ladronnes.

PLATE V. Nearer view of the "tripoli" showing the upper scoria-crag and middle "tripoli" deposits.

Photographed by J. E. Smith, of Socorro.

PALÆONTOLOGY AND THE BIOGENETIC LAW.*

By KARL VON ZITTEL.

Palæontology has long since ceased to place itself exclusively at the service of geology as the study of characteristic fossils. It has gradually grown into an independent branch of the biological sciences, and claims a share in all their movements and tendencies. The conclusive establishment of the doctrine of descent has evoked the most powerful revolution in descriptive natural history, influencing and transforming its whole method of research. No large palæontological work of to-day contents itself with the description of new forms, the comparison of them with those already known, and the arrangement of them in systematic order. To determine the generic relationships, the ancestry, the modification, and the further development, in short, the race-history or phylogeny of the organisms under consideration, is now regarded as essential, by many indeed as the chief end of palæontology.

*A paper read before the International Congress of Geologists, 1894.

SCORIA-CRAG AND TRIPOLI DEPOSITS.

As Darwin forcibly insisted, the doctrine of descent depends in no small degree on palæontological facts. Thus, the great similarity of the fossils occuring in strata immediately superposed one on another, e. g., the brachiopods, ammonites, and other molluscs, had made it difficult for geologists to determine the age of sedimentary rocks. In recent years a great number of closely-allied species have been traced through several superposed beds, stages or divisions of formations, their exact morphological relationships have been studied in the most careful manner, and thus the probability at least has been established, that we are here dealing with a genealogical sequence of blood-relations. To be sure these do not as a rule form complete chains, wherein mutation is linked with mutation and species with species. They are rather discontinuous series, of which all the members change in a definite direction and obviously form steps in a line of development, which culminates in the last extinct or still-existing representatives. Among the better-known series of forms I will only refer to a few. The succession of genera, which leads from *Hyracotherium*—perhaps, indeed, from the five-toed *Phenacodus*—through *Paloplotherium*, *Anchilophus*, *Anchitherium*, and *Hipparion*, to the single-toed horse, forms one of the most quoted and most beautiful examples of phylogenetic development. No less complete a series is presented by the genealogical tree of the camels, which already appear during the Eocene in North America, spread there in the Miocene and Pliocene, and then first emigrate to the old world. The pigs, also, and the Oreodontidæ, Anoplotheriidæ, Tragulidæ, and the ruminants studied in so masterly a manner by Rütimeyer, afford us more or less complete genealogical series, beside which may be ranged the crocodiles among reptiles, the Amioidei and Physostomi among fishes. If we glance over these phylogenetic series, we observe that the final terms are almost always distinguished from their predecessors by a more pronounced and distinctive differentiation; and since we are accustomed to assign a higher rank to a specialised organism in which every function is performed by a special arrangement, than to a creature which performs its functions with few and less complicated parts, phylogenetic development, as a rule, implies also progression and perfection. For the existence of

the chain of forms already mentioned, to which many others may be added, there is only one rational explanation, namely, that the various links in them have arisen one from another, and are connected by blood-relationship. Moreover, the similarity of the faunas and floras which are nearest to one another in geological age, as well as the geographical distribution of extinct and still existing plants and animals, can only be satisfactorily explained on the assumption of descent.

But, although an abundance of palæontological facts can be cited in the most convincing manner in favor of the theory of descent, on the other hand we must not forget that we know no point of origin for numerous independently arising creatures, and that the connection between the larger divisions of the animal and vegetable kingdoms is by no means so intimate as the theory especially postulates. The jubilation with which the discovery of *Archæopteryx* was greeted at the time shows at best that links had previously been wanting between two classes which among vertebrates undoubtedly exhibited the closest relationships. Further, *Archæopteryx* fills the gap between birds and reptiles only in a very imperfect manner, and affords no indication of the point at which the former have branched from the latter. It may, indeed, be maintained that we find ourselves to-day in greater uncertainty as to the origin of birds than we were twenty-five years ago, when Huxley's brilliant researches on the pelvis of the Dinosauria seemed to have found the bridge between the two classes. Links between the Amphibia and Reptilia are also still wanting. Perhaps they are to be found among the varied Theromorpha, but as yet palæontology cannot determine the phylogenetic modification of the amphibian into the reptilian type. No zoologist will deny that the Mammalia hold an entirely isolated position, separated by a wide gulf from birds, reptiles, amphibians and fishes; while among all known mammals it is not some old fossil genus, but the duck-bill, still living in Tasmania, which most reminds one of the more lowly organized vertebrates. Certainly we still know too little about the skeleton of the Mesozoic mammals, and especially the Allotheria, for us to form a final opinion on this point. But the warmest adherents of the theory of descent must at all events admit that extinct links between the different classes

and orders of the vegetable and animal kingdoms are forthcoming only in a small and ever-diminishing number.

Nevertheless, in the larger groups we know numerous series of forms, which not only bear witness to the great plasticity and adaptibility of their members, but also in their chronological order indicate the line along which modification has taken place in course of time. To be sure, much uncertainty and the personal equation of the authors attach to those genealogical trees that are based entirely on the morphological comparison and determination of the chronological sequence of the forms met with. "It is easy to accumulate probabilities, hard to make out some particular case in such a way that it will stand rigorous criticism," was Huxley's caution so long ago as the year 1870, in his classic address to the Geological Society of London; and one of the most spirited veterans in the field of mammalian palæontology decides in his last exhaustive monograph on the fauna of Egerkingen, that the creaking and crackling of leaves and branches already decayed does not encourage one to set foot in the hastily-explored forests of phylogenetic trees. None the less does the tracing of the hidden bonds of relationship exercise a fascinating charm over every investigator. All of us, indeed, are convinced that the mutual relationships of the extinct and still-living members of any large group of organisms may be represented, not in the form of an entangled network, but in that of a much branched tree.

In addition to the above facts there is still another series of phenomena which confirms the genetic connection of the palæontological chains of forms, and this was first observed, strangely enough, by one of the most distinguished opponents of the theory of descent. Louis Agassiz certainly regarded the fossil embryonic types as creative attempts which prophetically foreshadowed genera that appeared later with more mature characters. Fossil creatures with persistent youthful and even embryonic characters could not fail also to be noticed by the adherents of the theory of descent, but were regarded as favoring a view which recurred in very different forms in the philosophical literature of the first decades of this century and which has lately been precisely formulated by our great German zoologist, Ernst Haeckel, under the name

of the "Biogenetic Law." According to this the development or ontogeny of each individual is only a short recapitulation of the long course of ancestral history (phylogeny) of the species or family in question. There must, therefore, also be chronological series of fossil embryonic types which would correspond with the different stages in the development of a subsequently existing form; indeed, the separate divisions of a genealogical tree must correspond essentially with the ontogenetic stages of a determined course of development. If the biogenetic law were correct, embryology would thus be in a position to reconstruct, at least approximately, the primitive forerunners of each group of plants and animals; and these types should, if they were capable of preservation, also lie buried in the rocks.

If we consult palæontology, it shows that these surmises are by no means confirmed. There are, indeed, a great number of fossil genera which retain throughout life the embryonic, or, rather, the youthful characters of their existing allies, but it is only among the mammals, and to some extent among the reptiles, that I could name a complete series of forms following one another in time and belonging to the same line of development. The Eocene, Oligocene and, in part also, even the Miocene Mammalia, stand to their now existing allies, for the most part, in the relation of youthful forms, while they, almost without exception, exhibit at least some characters which are quickly passed through by their geologically younger successors in the embryonic or youthful stage. On the other hand they are, as a rule, destitute of the most striking peculiarities, such as antlers, bony processes, fusion of certain bones, reduction of the teeth or of separate parts of the skeleton; and it is not till we study more closely a series of related genera of different geological ages that we see how the differentiations and peculiarities of the existing representatives of any particular group have been gradually formed in course of time. But thus it is also possible to discover, in most of the mammalian orders, a number of primitive characters, which, while they frequently occur united in the oldest representatives of the group in question, also usually correspond to an embryonic stage of one of its living members.

The ontogeny of organisms now living would, for the rest, afford but an exceedingly unsafe basis for the reconstruction of ancient faunas and floras, since experience teaches that the biogenetic law is frequently veiled or completely obscured owing to various causes. Not seldom does it happen that of two nearly allied living forms the one passes through a series of continuous, successive stages, while development in the other takes place more by jumps. In the latter case the embryo is driven by peculiar influences to an acceleration of its development; it completely jumps over certain stages and thus renders unintelligible the historical (palingenetic) record preserved in the ontogeny of each individual. This falsification of development—or cœnogenesis, as Haeckel calls it—chiefly occurs when the adult individual manifests a high degree of differentiation and when the embryo has to pass through considerable changes to reach its final form. How unsafe and deceptive palæontological results would be if attained by embryological paths may be gathered from some random instances. What wonderful ancestors would be constructed for the crinoids by a zoologist who only knew the life-history of *Antedon*! The lowest portion of the family tree would have to present armless crowns, composed only of five basal and five oral plates, set on a stalk; then would follow genera with five large basals, five tiny radials and five stout massive orals; then forms with five arms, at first short and later on simply branched; and so on. But I will not further elaborate the picture. All know that it does not in the remotest manner agree with the facts of palæontology. What zoologist would conclude from the developmental history of the recent sea-urchins that the regular forms preceded the irregular, or again that the former had fossil ancestors of the type of the Perischoëchinidæ and Bothriocidaridæ? In the ontogeny of the cœlenterates there is no certain indication of the former existence of Cyathophyllidæ or Cystiphyllidæ. No observations of embryology would warrant our imagining the former existence of graptolites or stromatopores. No stage in the development of any living brachiopod informs us that numerous spire-bearing genera lived in Palæozoic and Mesozoic times. These few instances might easily be multiplied; but they may suffice to show how trivial are the discoveries

concerning existence in earlier periods of earth history that can follow from ontogenetic researches alone.

A further, indeed the practical, reason why ontogeny bears so slight a relation to geology and palæontology, lies in the fact that the earlier stages of development, with which modern embryology almost exclusively occupies itself, are not capable of preservation in the rocks, and that we can, therefore, never expect to find their fossil archetypes. The changes which occur between the embryonic and the completed adult stages have, at least among vertebrates, not yet received the attention they deserve, and it is these very changes that are of special interest to the palæontologist.

In spite of these hindrances, fossil embryonic types are not entirely wanting, even among invertebrates. The palæozoic Belinuridæ are bewilderingly like the larvæ of the living *Limulus;* the Pentacrinoid-larva of *Antedon* is nearer many fossil crinoids than is the full-grown animal; certain fossil sea-urchins permanently retain such features as linear ambulacra and a pentagonal peristome, which characterize the young of their living allies; among Pelecypoda, the stages of early youth of oysters and Pectinidæ may be compared with palæozoic Aviculidæ. Among brachiopods, according to Beecher, the stages which living Terebratulidæ pass through in the development of their arm-skeleton correspond with a number of fossil genera. Among completely distinct groups also, ontogenetic characters have been successfully traced. The beautiful researches of Hyatt, Würtenberger, and Branco have shown that all ammonites and ceratites pass through a goniatite-stage, and that the inner whorls of an ammonite constantly resembles, in form, ornament and suture-line, the adult condition of some previously existing genus or other.

Series of forms whose successive links correspond with successive stages of development in their youngest, still existing representatives are the only ones that still furnish us with an uncontestable picture of the path along which any given assemblage has evolved. These are the kind of genealogical trees that form the worthy goal of palæontology. From them a natural system will arise of its own accord. But from this goal we are, unhappily, still far removed. As a rule, our palæontological trees lack an ontogenetic foundation, and that

the foundation itself may be constructed in an arbitrary manner is best shown by the unsatisfactory condition of our ammonite-literature.

The time, it seems to me, has not yet arrived for the thorough reform of zoological classification on a phylogenetic basis. Among Protozoa and Cœlenterata there are absolutely no satisfactory fixed points for the phyletic arrangement of the various groups. Among Echinodermata it is proved that the correspondence in embryonic development between Asterozoa and Echinozoa is evidence of a common origin; but the classification of the various classes is as yet affected only to the smallest extent by the facts of ontogeny and phylogeny. The union of Bryozoa and Brachiopoda into a special phylum —the Molluscoidea, and their connection with the worms, depend entirely on embryological comparison: in their later development the two classes go so far apart that we can find no further parallel between them; and although the beautiful researches of Beecher, Clark and Schuchert on the phylogeny and ontogeny of the Brachiopoda will furnish a sound foundation for a new and better classification of the class, the first adumbration thereof is still somewhat doubtful. On the other hand, researches on the development of the shell in Mollusca are, without doubt, full of promise. What results we have to expect in this field is shown by the labors of Jackson, Hyatt, and Branco, though it must be confessed they still afford no sufficient basis for a classification of the pelecypods and cephalopods.

Palæontology has made its deepest mark in the classification of the Vertebrata. Here we frequently come across firmly-rooted genealogical trees. Phylogenetic and ontogenetic facts have effected the removal of the order Solipedia and the natural grouping of the ungulates. The discovery of the fossil Condylarthra and Creodontia has brought to light unlooked-for relationships between ungulates and carnivores. The remarkable fauna of the Puerco beds contains, according to Cope, almost completely indifferent types, which cannot be considered either as true ungulates, beasts of prey, or rodents, nor can they even be regarded as typical Condylarthra, Creodontia, or Lemuria: scarcely can they be dovetailed into the framework even of a geological classification, since they show relationships in the most varied directions.

And here we approach an important question of principle. The larger categories in botany and zoology are almost exclusively based on the investigation of forms that still exist; and it is only in those divisions where the fossil forms surpass the recent ones, in number or in variety of organization, that they, too, have been taken at all into account. As a rule it has been thought good enough to wedge in the extinct orders or families between the groups erected by the botanists and zoologists. Thus the foundations of the system remain intact. It is only recently that attempts have been made to reconstruct individual divisions of the zoological system, to a certain extent from below, on a palæontological basis. Thus, Scudder has established a sub-class, Palæodictyoptera, for all palæozoic insects, because they possess a series of common, indifferent characters and show as much morphological correspondence one with another as they do with the later Orthoptera, Neuroptera and Hemiptera, whose predecessors can already be clearly recognized among the palæozoic forms, although they have not yet attained the complete differentiation of their later descendants. Could we resurrect the numerous genera of the Puerco beds and place them among our fauna of to-day we should doubtless arrange them in one common order, more or less corresponding to the marsupials: for, like the marsupials, they possess characters that, at all events, point in the direction of orders more clearly differentiated later on, in which orders we are at present accustomed to enroll them.

If the zoological and botanical systems were now to be created for the first time, they would in many respects probably assume a different appearance. They would have to represent clearly the natural relationship and the derivation of the organisms. The geologically oldest representatives of any of the larger assemblages, which are as a rule also the most generalized and most primitive, would have to be united under a special name and would be regarded as the common root of the orders, families, genera, etc., proceeding from them. But it is only in a few cases that palæontology could furnish the materials required for a reform of this kind. As a rule, and especially among the invertebrates, the primitive generalized types are missing, and we should be obliged to

begin with those branches and twigs from our stems which are already more clearly differentiated and of which the majority stretch down as far as the creation of our own day. Here again, then, we should be led to ground our classifications on those organisms of which we were in a position to investigate not merely certain fossilisable elements, but the whole anatomy, physiology and embryology.

The function of classification, however, is not only to arrange organized beings according to their relationship, but also to facilitate our survey of life's infinite variety of form. It was to this intent that the older systematists constructed their various categories. They it is that have historic rights; and just as little as we geologists are inclined, without urgent need, to alter the historic conceptions and the divisions that have been handed down to us, just so little is it advisable to be incessantly remodelling the systems of botany and zoology. The doctrine of descent has, of course, violently shaken the solid framework of the older classification. The ideas—variety, mutation, species, genus, family, order, etc.—have become indefinite and unstable; the boundaries between the systematic groups are constantly being displaced, and bonds are burst that were once tightly bound. An important part is played to-day by subjective opinions, and when I think of the anxiety with which we elders—we who received our scientific education before the Darwinian era—proceeded to found a new species or genus and compare it with the light-hearted manner in which to-day species, genera, families and orders are set up and again put down, I am herein most forcibly impressed by the difference between then and now. The domination of the Linnæan and Cuvierian principles threatened systematic biology with soulless paralysis: the unbridled subjectivity of recent times may easily lead to anarchy. When, after investigating a certain number of forms, every author feels called upon to reform the classification and where possible to introduce a new terminology, then arises the danger that we shall lose our comprehensive survey of the richly varied organic world and that we shall use a language intelligible only to the most narrow specialists and repellant to every layman.

With this warning let me conclude. The theory of descent has penetrated the descriptive branches of natural science with new ideas and set before them a nobler goal; but we should never forget that it remains only a theory and one that has to be proved. I have tried to make plain how greatly it is indebted for its establishment to palæontologic research; only I dare not conceal how many gaps are constantly brought to light in the very process of our argument. Science strives in the first place for truth. And the more clearly we keep ourselves conscious of the insecurity of the foundation on which our scientific theories rest the more actively shall we bestir ourselves to strengthen it by new observations and new facts.

[*Natural Science, May, 1895.*]

THE RETREAT OF THE ICE-SHEET IN THE NARRAGANSETT BAY REGION.

By J. B. WOODWORTH, Cambridge, Mass.

(Plate VI.)

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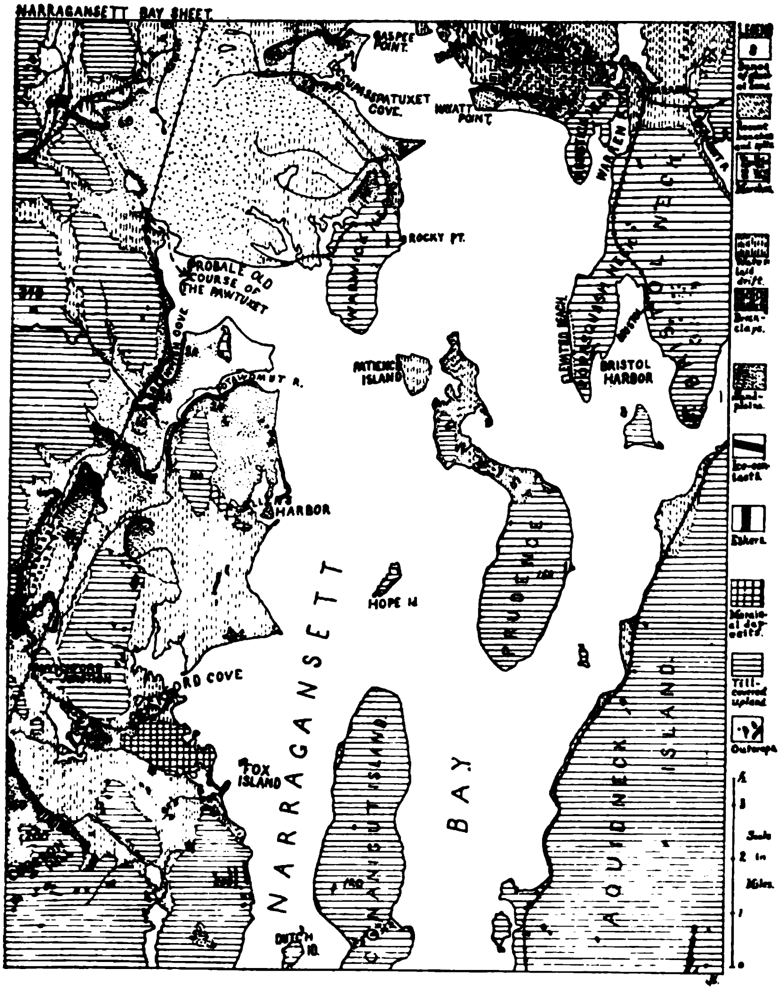
CONTENTS.

INTRODUCTION.

This paper is intended to give an account of the glacial sand-plains, with their attendant morainal accumulations, which constitute the greater part of the stratified drift depos-



THE RETREAT OF THE ICE-SHEET
IN THE NARRAGANSETT BAY REGION.

its bordering Narragansett bay. The studies here presented will appear in a less detailed account, and without the theoretical considerations here given, in a forthcoming atlas folio descriptive of the Pleistocene deposits of the Narragansett Bay atlas sheet, the mapping of which was done under the direction of Prof. N. S. Shaler. It should be stated that while that geologist is in full accord with the author as to the nature of the deposits here discussed, the author alone is responsible for the views which are here set forth regarding the circumstances of the origin of the glacial sand-plains and their attendant deposits.

The passenger by rail from Boston or Providence southward along the Shore Line cannot fail to notice a certain repetition in the landscapes observable from the car window. Going from north to south the views may be summarized as follows:

1. Lowland or valley, from one to five miles wide, either boulder-strewn and marked by mounds of gravel and an occasional esker or occupied by sluggish streams and swamps, and terminated rather abruptly on the south by the next.

2. A terrace or steep bank facing northerly, often hummocky or kame-like. The train plunges at once into a deep gravel or sand cut. From the edge of the terrace the skyline of the cut gradually sinks to the southward and in a few minutes a view may be had out over the surface of the sand-plain. At a distance varying from a quarter of a mile to a mile this plain terminates in more or less well defined lobate spurs resting on ground of a variable nature, often boulder-strewn, but sinking usually at a short distance into a swamp, and in general repeating all the features described under the first heading.

An analysis of these sand-plains shows that they characteristically have the steep northern aspect with cusps or kames indicating the deposition of the materials along and against the margin of the ice-sheet. Along the line of extension indicated by this contact with a now-vanished ice-wall, there are usually found other sand-plains, the accumulations thus marked forming belts from a quarter to half a mile in width, roughly concentric to the outer moraines along the southern coast between point Judith and cape Cod.

The sandy tracts between Providence and the mouth of Narragansett bay, first referred to the Tertiary, have long been known to be late glacial accumulations. They were referred to the Champlain by Dana. In this paper it will be shown that these sands and gravels represent successive stages of retreat of the border of the ice-sheet northward across the bay region; that the southernmost of these deposits is the oldest and the northernmost the newest; and thus that they are not valley trains. In general terms their age may best be stated as newer than the Elizabeth Island or Cape Cod moraine and older than the Cape Ann moraine of Tarr. The accompanying map (plate VI), traced from the Narragansett Bay atlas folio of the U. S. Geological Survey, presents the distribution of the sand-plains in that area and exhibits by special designations the position of the ice-contact slopes or moraine terraces in accordance with a plan proposed in my recent paper on eskers.*

Two stages of moraine building have been long recognized south of the field here described, an outer moraine including the superficial deposits of Block island and an inner moraine, here named the Charlestown moraine, skirting the southern coast of Rhode Island and forming the tip of point Judith.

RETREATAL DEPOSITS ON THE WEST SIDE OF THE BAY.

Narragansett bay sunders several glacial deposits that were evidently formed along ice-fronts more or less continuous across this inlet, so that it seems advisable to describe in succession the deposits of each coast from south to north and then to attempt their correlation.

THE CHARLESTOWN MORAINE.

This name is employed here for that portion of the inner of the two moraines early recognized along the southern coast of New England. It extends the length of the southern coast of Rhode Island from Fisher's island to point Judith. The moraine is mentioned here for the reason that it has been supposed to extend northeastward into the region of moraines about Wickford, R. I. The tracing on the ground of the ice-contacts shows that other morainal belts come into the region about Wickford from the southeast, so that there was in that

*Some Typical Eskers of southern New England, Proc. Boston Soc. Nat. Hist., vol. xxvi, 1894, pp. 197-220.

district a re-entrant angle in the front of the great ice-sheet, the position of which embayment is further marked by interlobate moraines of a bouldery nature extending northward along the western side of the bay essentially as was suggested by Chamberlin several years ago. Furthermore, the fact that the land for three miles north of point Judith is composed of glacial drift, mostly a dense blue clay, exceptionally gravelly and interpolated with stratified gravels, and having a low knob and basin topography, indicates the southward turning of the Charlestown moraine in this direction.

THE SLOCUMVILLE STAGE.

This stage of the ice-retreat is believed to be later than that of the Charlestown moraine. It is marked by a moraine terrace extending from the west of Wickford Junction southeastwardly along the northern base of Congdon hill, rising from 150 to 160 feet above sea level and from 60 to 100 feet above the low ground of intraglacial* drift at its base. From this moraine terrace or ice-contact slope an apron of sand and gravel stretches southwestward by Slocumville on the Shore Line railroad beyond the limits of the Narragansett Bay sheet.

Southeastward from Congdon hill, where the ice-front rested against the crystalline escarpment of the western border of the Carboniferous basin, the moraine is not well defined. The road to the top ascends the crest of a short esker. An isolated patch of water-worn sand and gravel, beset with large boulders, on the ridge back of Saunderstown, R. I., is probably of morainal origin and marks the continuation of this moraine. Eastward of this point it has not been found. It is probable that the stand of the ice-front along this line was due to the resistance offered by the wall of the Carboniferous boundary. East of Saunderstown there is an open valley southward to the sea, which would have permitted the southward extension of the ice-front or the deposition of washed drift without high lying terraces.

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*Intraglacial (see Dana's Manual of Geology, fourth ed., 1895, p. 958) is here used for drift deposited in the field occupied by the ice, in contradistinction to extraglacial drift which has come to rest on ground not actually covered by the ice when it was deposited. According to Prof. Dana's use of this term, however, it would be synonymous with englacial, as Prof. Chamberlin designates the drift enclosed in the lower part of the ice-sheet.

Westward in the region of the interlobate axis this moraine probably connects with the Queen's River moraine described by Woodworth and Marbut in *The Journal of Geology*.

THE WICKFORD SUB-STAGES.

Interior to and northward of the Slocumville stage of retreat there are several subparallel ridges and terraces of stratified drift and mounds of till with occasional frontal overwash plains. These accumulations seldom exceed twenty or thirty feet in altitude. The till ridges and knobs are well developed in the vicinity of the railroad station at Wickford Junction. On the west of the railroad there is exhibited the characteristic relation of submarginal till mounds to the sand-plain formed outside of the ice as indicated in the appended section (figure 1). The fosse between the head of the sand-plain and the till mounds is a marked feature on the island of Nantucket. Other instances are to be found in

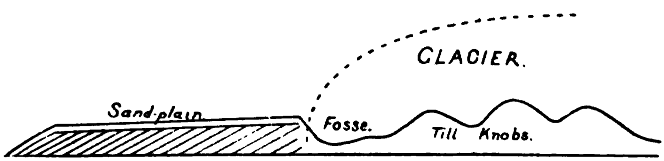

FIG. 1. Section of frontal sand-plain, with ice-contact slope, showing intraglacial position of till knobs of the moraine.

southern New England where the same relation exists and where the contact slope at the northern head of the sand-plain serves as a datum line for discriminating intraglacial from extraglacial deposits.

Wickford cove is surrounded on the south and west by unimportant but recognizable morainal masses. Near Belleville there is a small outwash plain surmounting the moraine. The surface of the plain is about 100 feet below that of the Slocumville plain. So marked a difference of level between stages of retreat with a minimum of difference of time can hardly be explained on the hypothesis of control by sea level during submergence. The level in the two cases is obviously determined largely by local topographic conditions.

THE DAVISVILLE STAGE.

In the vicinity of Davisville, west of the railroad, there occurs a high isolated mass of gravel, with steep northern slopes and a gentle southward incline in the form of a fan. The contour of this knob and its elevation are approximately in-

dicated on the original atlas sheet. The deposit appears to be a detrital cone built at the front of the ice by a supergla-cial or tunnel stream. The morainal terraces about its north-ern slopes are marked and form a group of two. East of this deposit is another similar smaller deposit not so readily diagnosed. Eastward in this line a low morainal accumula-tion extends southeastward on the south side of Allen's Har-bor, probably the extension of this ice-front.

THE POTOWOMUT STAGE.

North of the preceding and skirting the southern or right bank of the Potowomut river is a series of sand-plains, with a distinct ice-contact or moraine topography, from the sum-mit-line of which the surface of the deposits slopes southward. The opposite or northern bank of the river is uniformly lower and moulded at various points in the form of the frontal or marginal topography of a later series of sand-plains, the Greenwich Cove stage of this report. The estuary of Poto-womut river is simply the deeper submerged portion of the depression at the head of the frontal deposits of the Potowo-mut stage. The ice-front of this stage formed a loop north-ward around the till-covered upland just west of Allen's Harbor. At two points the Potowomut line of frontal accu-mulations is broken by streams flowing inward to the fosse or depression at its northern base. The Potowomut river flowing northward in a line with Greenwich cove, turns abruptly to the southeast as soon as it has passed through. and where it again turns to the northeast it receives another tributary also flowing to the north. The sand-plain between the two north-ward flowing streams is in large part boulder-strewn, as if by an advance of the ice-sheet after the completion of the sand-plain. The northward flow of the small streams toward the retreating ice-front is believed by the writer to be due to the occupation of this part of Narragansett bay by standing ice.

GREENWICH COVE STAGE.

Greenwich cove is an elongated indentation of the coast-line to the southwest, the sides of which are typical ice-con-tacts, except where the undercutting of the slope by wave action has destroyed the original glacial topography. Between the ice-tongue which filled the cove and the hills on the west,

coarse gravels were deposited, now in the form of a terrace, on which the city of East Greenwich is partly built. Potowomut Neck and the large sand-plain south of Potowomut station belong to this stage.

This cove marks the site of the last deposits about the finger-like projection of ice which lay along the line of the railroad between East Greenwich and Wickford Junction. The gradual shrinking of this mass is clearly brought out by the successive stages of deposits corresponding to the frontal and lateral moraine terraces of Gilbert's nomenclature which lie in this field. Frontal lobes are distinctly marked in the small sixty-foot plain at the southern end of Greenwich Cove. On the east of this plain is a distinct trough from the southern end of the cove to the Potowomut valley. This trough is a continuation of the line of the stream which enters the cove from the northwest. The lower course of this stream is terraced, showing that it has cut down its bed since the construction of the Greenwich Cove plain and terrace. The evidence from this locality appears to the writer to indicate that the trench above described marks the extended course of the existing stream at a time when the block of ice standing in the cove forced the waters from the upland to pass out across the sand-plain by obstructing drainage northward into the present cove, and so into the bay. Later, when the ice melted out of the cove altogether, the drainage was northward, as at present. The evidence which supports this conclusion also carries with it the necessary implication that the Greenwich Cove sand-plains were at least as high above the sea-level at the time when this trench was formed, as they now are. The relative hights of the land and sea are again considered at the end of this paper.

The stages of retreatal deposits ending in Greenwich cove illustrate the shrinkage and final disappearance of a tongue of the ice and its change from a broad east and west mass to a narrow block or tongue with a long north and south extension, such as characterized the ice-blocks which gave rise to the steep-sided ponds in sand-plains. In this nearly ideal development of sand-plains and terraces, Greenwich cove stands as the ultimate stage, with lateral terraces facing each other across a depression, occupied by the waters of the sea.

Carrying out the terminology familiar to everyone, the Potowomut sand-plains form a penultimate series; and the Davisville cones are antepenultimate members in this series of regularly progressive retreatal deposits.

OCCUPASSPATUXET COVE STAGE.

The depression in which lie Occupasspatuxet cove, Spring Green pond, and the connecting stream, has a relatively steeper and higher southern than northern bank. The contrast between the two slopes is greatest on the east in the cove, where the depression is widest. The southern bank marks the head of the Occupasspatuxet plain and stage of ice retreat. On the southern shore of Spring Green pond (a body of water retained by a dam on the line of the road), and at its eastern end, the bank, having here an east and west extension, is steep and comparatively smooth, being but slightly gullied or cuspate. Between the highway and the railroad the bank becomes more cuspate; and, beyond the railroad, it turns gently to the south of east, and maintains this course to the shore of the bay. Throughout, the materials are, at least at the surface, rather fine sands with a few pebbles and rarely a cobble six inches in diamater, and more rarely a fragment of sandstone over a foot in length. Evidently this bluff marks the contact with the margin of the ice at a time when sluggish streams were carrying to the front little or no coarse waste. Near the east end of Spring Green pond, a cut in the head of the sand-plain showed cross-bedded sands divergent upward to the south, indicating, probably, outwash from beneath the ice. In the fosse, just west of the railroad bridge, south of Spring Green station, a boulder upwards of eight feet in length forms a part of the glacial drift which came to rest upon the bottom when the ice between this and the next frontal stage melted out. Southward the sand-plain is level-topped.

PASSEONKQUIS POND OR GASPEE POINT STAGE.

This contact between the ice edge and its frontal deposits is marked by the depression known as the Passeonkquis pond, the cross-section of which shows a higher and steeper southern than northern bank. The south bank is as steep as the materials will stand, while the northern bank exhibits the low, lobate aspect of a frontal sand-plain of later date. Inward

from the coast, the relief is less distinct, but the contact-line is marked by the furrow occupied by a small brook which is traceable westward, passing some 600 feet south of Baker station, to the low mound of gravelly till which forms the northern face of the deposit delimited on the map by the forty-foot contour line. This latter portion of the front is a morainal phase; and two cuts, one where the railroad and the other where the carriage road cross the deposits, show boulders from three to five feet in diameter commingled with the gravelly till. The head or terrace itself does not rise more than ten feet above the fosse, and the back-slope is very gentle. Without the strong evidence of ice-front conditions exhibited in the washed phase of the line near Gaspée point, it would be difficult, perhaps, to maintain in New England the view here set forth. This plain, west of the railroad station, grades down rather steeply and is scattered over west of the carriage road with Carboniferous waste in fragments often exceeding six inches in diameter, all the evidence going to show the morainal nature of the deposit. The front comes down to the Spring Green pond fosse with traces of lobes. It is probable that this front has been somewhat modified by the drainage through this east-west depression, both that contemporaneous with the Passeonkquis stage and that which has taken place since.

PAWTUXET STAGE.

It is obvious from an inspection of a map of this region that the Pawtuxet river in running from the crystalline uplands west of Narragansett bay takes an indirect course to its debouchure. That this is not its preglacial course is also shown by the existence of rapids or falls at the point where it escapes into the sea at Pawtuxet. A diagnosis of the sand-plains, through which the course of this river is laid, shows that, like the Potowomut to the south, its path depends upon the occurrence of a well defined fosse at the head of a series of nearly synchronous sand-plains which are here denominated as the Pawtuxet stage of ice-retreat. The river follows this northeastward and backward course for about six miles, while its preglacial channel seems to have passed into Greenwich bay along the line of Gorton's pond and Apponaug river. (See dotted course on plate VI.)

This line of retreat exhibits both phases of frontal deposit. A moraine occurs west of Pawtuxet station in the area delimited on the Providence atlas sheet by the 60 and 80 feet contour lines. The surface is here cast into mounds and the material is till with surface boulders of conglomerate from five to six feet in diameter. Surrounding the morainal accumulations proper are sand and gravel deposits, in the nature of overwash plains on the south and of sandy moraine terraces on the north.

Westward the southern bank of the river is clearly for the major portion of its extent and elevation a characteristic sand-plain head, with kames and elongated hollows. these last marking the site of irregular projecting tongues of the ragged edge of the ice-sheet. Even beyond the line of contact with the main mass there are isolated hollows marking similar enclosed or buried remnants. Some of these depressions are drained by small brooks northward into the Pawtuxet.

Where Elmwood avenue crosses the Pawtuxet river the head of the Pawtuxet plain and the frontal aspect of the next succeeding stage on the north are tolerably well contrasted. The Pawtuxet sand-plain is broken down into kames with here and there a distinct steep northward slope, all of which show (except at their base) no signs of the erosive action of the river, whose flood-plain is sharply marked topographically in the trough at their base. The criteria for the recognition of successive stages are distinctly shown. The head of the plain is higher than the opposite northern bank of the river, and the deposits on the south bank are perceptibly coarser than those on the north bank.

This bank curves southwestward beyond the confines of the Providence sheet on to the Narragansett Bay sheet. In the vicinity of the Rhode Island state farm, Pontiac, and Natick, the eastern or southern bank of the Pawtuxet is distinctly steeper than the opposite bank, but it is also obvious that in places the slope alone is due to postglacial erosion, so that this criterion of the ice-contact is locally wanting; but the hight and conformation of the sand-plains confronting this slope and their relation to the deposits on the left bank of the river make it strongly probable that the course of the Pawtuxet from where it enters the glacial plain at Natick to its

mouth is throughout determined by the stand of the ice-front. The sand-plains of this stage between Natick and the State Farm have their head from 50 to 60 feet above the sea and slope to the southward and eastward toward Greenwood and Hills Grove. Gorton's pond marks the site of a large outlier of the ice which had not yet melted when deposition at the Pawtuxet stage was practically completed. Duck and Little Sand ponds also mark the site of lingering ice masses. At Hills Grove there are traces of the intraglacial bouldery or till deposits of a previous stage which were so high as not to be covered by the sands of the Pawtuxet stage.

The intraglacial deposits of this stage are fairly well shown in the valley of a small brook north of the villages of Natick and Pontiac, where the gravels and sands of the next succeeding stage were not carried southward to suffuse them. In this valley are short eskers and kames, evidently marking deposits made inside the ice while the large Pawtuxet plain was being deposited outside of the glacial sheet.

Retreatal Formations on the Central and Eastern Shores of the Bay.

Deposits of stratified drift, either in the form of sand-plains deposited against the edge of the ice-sheet or in the form of kames built up within its decaying margin, are not well developed either on the islands in the axis of the bay or on the eastern shore from Sakonnet point northward, though in the region of the Taunton river and the country westward through Barrington the development of stratified drift quite equals that of the west coast.

Definite frontal deposits of any kind are unknown on the island of Aquidneck. The area of this island appears to have been bared of ice and above the level of deposition by glacial streams at the time drift deposits were laid down in the retreat across the bay. At the northern end of the island occurs the remnant of a sand-plain, the connection of which with the ice retreat will appear clearer when considered with the deposits of the east coast.

On the island of Conanicut the surface deposits are mainly upland till, except for a small area near Sand point, opposite Wickford cove. The contour of this deposit is not sufficiently clear to correlate it with the class to which it belongs, but it

has the appearance of being a remnant of a sand-plain made in extraglacial waters.

NAYATT POINT STAGE.

Between Rumstick neck and Nayatt point there is a narrow ridge of stratified drift deposits, which, for a portion of its length, exhibits the characteristic cross-section of typical glacial sand-plains. The best exhibition of this feature is to be seen about half a mile west of Rumstick neck. The road, going west, skirts the base of the sand-plain head, which is here cast into kames, and occasionally rude esker-like deposits mounting on the northern slope. From the summit a plain extends southward, gradually giving way to well marked, though not trenchant, frontal lobes, which descend to sea level and are now being cut into by the action of the waves. Again, at Nayatt point, there is a similar section, but sea-erosion on the south and west has removed the frontal lobes. These two sand-plains attain an elevation of about 50 (?) feet and agree in this respect with the next northern or Barrington stage. Great interest attaches to the Nayatt stage from the nature of the deposit made at the ice-front between the well formed sand-plains. These are connected by a low ridge having some resemblance to a till-covered surface. This ridge has an elevation of about 30 feet above the sea and evidently marks a point of minimum deposition along a nearly straight ice-front.

These plains merge eastward into the Rumstick neck north-and-south gravelly ridge, the origin of which is obscure. The abundance of boulders and the presence of kames suggest its deposition in the marginal portion of the ice-sheet, probably on the southeast side of a re-entrant angle.

BARRINGTON STAGE.

That the front of the ice lay for a time along the south side of the Barrington river, between the villages of Barrington and Drownville, R. I., is shown by the well-formed glacial sand-plain which occupies this interval. The Providence, Warren and Bristol railroad runs along its southern margin. On the north, the plain rises abruptly from the low and almost flat intraglacial ground, broken only by a winding, low, wide, ill-defined esker, which is confluent with the plain. The outlines of this esker are roughly shown by the 20 and 40 feet

contour lines of the survey map. The head of the sand-plain is about 50 feet above the sea; it is broken down into local kame-like forms, but in some places is a sharply defined more or less cuspate wall, marking the contact with the edge of the ice-sheet. From the summit-line the deposit slopes southward, the surface being slightly creased, with distinct lobation along its southern margin. In one place, near the front, the plain is broken by a deep ice-pit, due to a remnant holding over from the Nayatt Point stage until the completion of the plain. The detritus near and at the head of the plain is as coarse as cobble stones, but toward the lobate margin it becomes a finer mixture of sand and gravel and graduates southward across the railroad named into sands and clays, the latter being the beds worked in the Barrington clay pits. The plain is nearly one and a half miles wide, measured along the vanished ice-front, and is three-fourths of a mile long in its greatest southward prolongation; and its contact slope is just one mile north of the previous Nayatt Point stage ice-contact. Assuming the plain to have an average thickness of only 40 feet, for the portion above sea-level, the delta deposit contains 557,568,000 cubic feet, which is equal to 20 feet of sediment deposited on one square mile. But there is the clay in front of the delta and beneath its frontal edge, which is equivalent, roughly, to 60 feet on the square mile, making a total of 80 feet on that area. The Mississippi, according to Humphreys and Abbot, deposits annually 260 cubic feet on one square mile of surface in its delta. The Barrington plain is clearly the product of a stream flowing out of the ice along the path marked by the esker. The revealed structure of the related esker fans in New England, as pointed out by Davis and others, indicates rapid deposition, such as might well be accomplished in a single summer season or period of uninterrupted melting, a length of time probably lasting through less than eight months of the year. Assuming this estimate for the basis of a comparison, then during this time 80 feet of sediment would have been laid down, or about one-third of that deposited by the Mississippi in twelve months. At the rate of deposition for eight months, the Barrington glacial detritus would have amounted to 107 feet per square mile in a year, or about 40 per cent. of that deposited by the Mississippi in the same

time. While an estimate of this kind must necessarily be vague, it serves to give an idea of the flooded character of the streams flowing out of the ice. It does not follow, however, that the proportions between sediment and volume of water discharged in the two cases here compared are to be considered equal. The glacial stream was a narrow one, probably not over 150 feet wide in its intraglacial course, as is indicated by the esker; but it was flowing with a strong current, which enabled it to transport cobbles six inches in diameter to the head of the delta.

The esker. The winding broad ridge which joins the Barrington sand-plain on the north is not typical of its class in many respects. Rising out of a group of intraglacial deposits or rude kames on the north, this ridge runs southward for half a mile with only here and there the steep sides of a typical esker.* In general the esker is so wide as to preclude the notion of its deposition beneath an arched channel; and it seems probable that it was deposited in a passage open to the sky above, contemporaneously with the building up of the sand-plain which was being formed outside of the ice. Near its junction with the sand-plain the esker turns abruptly to the eastward and becomes higher and flat-topped, being separated originally from the sand-plain by a narrow piece of ice from 150 to 200 feet wide; thence it turns abruptly southward and joins the middle of the plain. At the junction the esker is deeply notched.

Correlation of Deposits on Opposite Sides of the Bay.

The correlation of deposits made along the line of the ice front at any particular stage of retreat is attended with certain difficulties even where there is a continuity of deposit indicated by a continuous moraine terrace or ice-contact slope at the head of sand-plains, since it is not certain that all portions of the extended series of more or less confluent plains were laid down at one time. Accepting, however, general continuity of more or less marginally confluent frontal plains with occasional morainal heads as evidence of a given stage of retreat, correlation with disconnected deposits of a frontal nature may be made by using the following criteria:

*Some Typical Eskers of southern New England, Proc. Boston Soc. Nat. Hist., vol. XXVI, pp. 197-220.

1. Identity of alignment indicates probable identity in age. In the Narragansett bay region this is the most reliable and probably the only criterion which can be used.

2. Identity of elevation of the limiting level of delta construction in the same field without barriers indicates deposition in the same water-body or at the same stand of the land with reference to the sea, and hence approximate synchronism. Allowance must be made for postglacial deformation.

3. Identity as regards the number and kind of post-depositional changes indicates approximate identity in date of origin.

The sand-plains of Narragansett bay are so nearly of the same epoch that it is difficult to distinguish differences in geological history, and this method of differentiation has not been applied.

Matched by alignment, the following sand-plains appear to be clearly along the same front:

West side.	*East side.*
Gaspee Point stage.	Barrington stage.
Occupasspatuxet stage.	Nayatt Point stage.

The sand-plains and cones to the south on the west side of the bay are not so clearly traceable into connection with the plains and terraces of which traces are recognizable on the eastern side of the bay. At present little can be said of this eastern region except that the retreat of the ice-front is marked by the existence of a kame-like terrace along the Fall River shore and by a partially submerged plain at the northern end of Aquidneck island. That these are frontal deposits is indicated by the occurrence of till on the western shore of the Taunton river. A similar distribution of drift is found on Watuppa pond east of Fall River. The eastern shore of the pond exhibits a remnant of stratified drift of extraglacial deposition: the western side of the pond is till; between the two deposits probably lay the ice edge. These two stages, the Watuppa and the Fall River, on the Fall River atlas sheet, are probably to be correlated with some of the frontal stages between Greenwich cove and Wickford.

Westward the sand-plains of the bay are clearly to be correlated with boulder belts, but the details of this correlation are not yet worked out.

Later Stages of the Retreat.

The next three frontal stages are altogether on the Providence atlas sheet and are plainly indicated by the topography as expressed in the contour lines.

THE ROBIN HILL STAGE.

The narrows of the Providence river south of the city of Providence are formed by the hills of stratified drift of which Robin hill is the culminating point. These deposits attain an elevation over 100 feet above the sea and range in an east-west direction for about a mile and a half, with a breadth exceeding one-half mile. Throughout where cuts have been made in laying out streets, the deposits show stratification, much of which has been displaced by settling, evidently brought about by the melting out of buried ice. South of the deposit stretches the Elmwood sand-plain, which declines southward to the Pawtuxet river. The high morainal head and low overwash frontal plain are conspicuous features of the west side of the bay as seen from a passing vessel. On the east side of the bay, at India point, there are traces of the same deposits, but they are nowhere so well developed. Westward of Robin hill the frontal conditions merge into the Mashapaug pond area, where the front cannot be well traced

THE FORT HILL SUB-STAGE.

Fort hill, at Fox point, exhibits a thick section of water-worn but ill-assorted drift of a morainal type, sharply separated above from a superficial coating of stratified drift varying from nothing to five or six feet in thickness. Southward from the old fort there is a sand-plain, showing that the ice-front for a time rested against the east bank of the mouth of Seekonk river at this point. Frontal conditions are also indicated on the west side of Providence river in this same belt by the steep northern slopes of the sand-plain in the vicinity of the Rhode Island Hospital.

CENTRAL FALLS STAGE.

This stage of ice retreat is indicated by the remarkably well developed sand-plain, esker, and lateral terraces, northwest of the city of Pawtucket. The contours of the Providence atlas sheet bring out in a clear manner the essential features of these interesting deposits. The head of the sand-plain marks the southern limit of the ice in the Blackstone

valley at this stage. The esker was apparently formed in a channel in the ice, the southern part of which was probably arched over, while the wide northern portion was, at least in its later stages of growth, open to the day. The ice-sheet had disappeared from the hills on the west and lay in the valley as a mass so narrow as to allow on the west the formation of washed deposits back of Lonsdale and on the east a similar terrace on the site of Valley Falls. This is the most distinct of the frontal deposits formed at this stage. Probably the extensive sand-plains east of the Blackstone river in the towns of Pawtucket and Attleboro and along the line of the Old Colony railroad belong to this time, or to a somewhat later stage of the retreat.

Sand-plains between Providence and Boston.

Northward there are belts running northeast and southwest along which sand-plains with ice-contacts occur. Attleboro, Mass., is located on such a plain: so also is Mansfield; north of this is the Sharon plain; and there is another northeast of Canton Junction, and one at Readville,—all being in Massachusetts, on the line of the Old Colony railroad between Providence and Boston. In general, it may be said that the sand-plains described as occurring between Point Judith and Providence are parts of a succession of morainal and washed deposits which are traceable eastward and northeast toward the interlobate axis which passes up the western shore of Cape Cod bay toward Scituate. Mass. In another paper I hope to present a map of these retreatal deposits.

The Space between Stages of Retreat.

The several stages of retreatal deposits in the Narragansett bay region, from near Wickford northward, manifest a tendency, in the ice-front, to be bordered by sand-plains at intervals of about one mile. This regular recurrence of a halt in the ice-front with sand-plain building calls for an explanation, but it does not appear evident to the writer what processes brought about this sequence. It is apparent that the interval is not connected with seasonal changes. Davis has shown that during the growth of the Woodland sand-plain, near Boston, the ice-front did not melt back more than a few yards during the outward extension of a delta to the distance of two or three hundred yards. It is reasonable to suppose that

the sand-plain construction went on during summer rather than winter conditions, that is, during times of most rapid melting. We cannot, therefore, assume that successive sand-plains one mile apart represent annual halts of the ice-sheet; for this would postulate that during the intervening winter the ice-front receded one mile, a result, to say the least, incompatible with the rate of melting during the construction of a single sand-plain. It seems most likely that the interval in this region is dependent upon some cause tending to reproduce the same conditions of drainage at regular space intervals on the border of the ice-sheet, without definite control by the passage of time.

The occurrence of kame-like mounds in the intraglacial field back of the sand-plains suggests the overlapping of the delta deposits upon the attenuated if not baseleveled margin of the ice so as to protect the ice beneath from the sun's rays. The identity in the materials of the sand-plains and these kames corroborates this view. The ice back of the overlapped zone would melt away in time, and the streams would tend to flow in the depression at the inner side of the overlap and so would be diverted for a time to one side. In the open space thus formed sand-plain building may be renewed after a time. In this view, the interval between successive sand-plains depends upon the width of the overlapping frontal drift plus the width of the depression produced interior to this overlap by the melting of the uncovered ice.

That something analogous to this supposed course of events took place in Barrington, R. I., is indicated by the occurrence of the ice-pit in the margin of the Barrington plain, by the kames along the contact slope of the Nayatt Point plains, and by the wide-winged form of the Barrington plain. All these indications are explained if we suppose that the marginal portion of the ice-sheet at its contact with the head of the Nayatt Point plains had not yet melted out when the Barrington plain was nearly if not quite completed.

Relation of the Sand-plains to Sea Level.

There can be no doubt that the Nayatt Point eastern sand-plain was deposited in a body of water whose surface was approximately fifty feet higher against the land than the present sea level, if it was not still higher. A more important pre-

liminary question than that of the absolute upper limit of this water body is the question whether this water was at sea level or was above it; for in the latter case it would not be an indication of the stand of the land with relation to the sea.

At first sight the evidence appears to favor submergence of the land. There are, however, several significant facts to be observed in the distribution of the lingering masses of ice in this field, pointing to the possibility of ice dams, which should not be overlooked. There is a marked tendency in the Narragansett bay region toward long north and south depressions held open by ice while the sand-plains and eskers were accumulating. These depressions may be seen near Central Falls, about Providence, and in the long trench west and north of Wickford Junction. It is obvious that the ice remnants in the troughs of the bay were last to melt out because the ice was there thickest. The tongue which ended in Greenwich cove indicates by its sand-plains the length of time taken for its liquefaction. Had similar but larger masses remained in the principal passages, they might well have served to hold up the waters which came from the ice into this drainage channel and to convert it into a temporary lake. If this was the case, the ice-front, when being melted back past Nayatt point, was deeply indented there by a northeastwardly re-entrant angle, the southern side of which would be formed by an ice-lobe extending at least to Warwick neck. There is no evidence, however, excepting perhaps a moraine southeast of the angle supposed, that I have been able to find in the right places to support this hypothesis. It may, or it may not, be true; and therefore the same must be said of the alternative hypothesis of marine submergence by a depression of the land to the amount of about fifty feet.

On the other hand, there seems to be good evidence, as noted on page 156, that during the immediately preceding Greenwich Cove stage of the glacial recession the land here stood fully as high as now. We have thus an independent ground for the assumption that the sand-plain at Nayatt point was deposited in a glacial lake, being therefore no indication of contemporaneous land depression and submergence.

ORIGIN AND AGE OF THE LAURENTIAN LAKES AND OF NIAGARA FALLS.*

By Warren Upham, St. Paul. Minn.

CONTENTS.

Preglacial Condition of the St. Lawrence Basin.

During the later half of the Cretaceous period nearly all the region which now forms Minnesota and the drainage basin of the Missouri river was depressed and covered by the sea; but the contiguous region now forming the basin of the St. Lawrence continued through that time as dry land, which has been its condition ever since the Appalachian revolution terminating the Paleozoic era. On the east half of the continent the principal drainage system that carried its detritus west to the Cretaceous ocean is probably marked by the chain of great lakes from Ontario to Superior, the west end of which is close to the east border of the broad belt of Cretaceous submergence. At that time, and onward through the greater part or all of the Tertiary era, much of this eastern land area appears to have been elevated at least several hundred feet above its present level, so that streams eroded the deep basins which are now occupied by these lakes tributary to the St. Lawrence, but which then probably had a continuous westward descent. The lake basins appear to be due to epeirogenic movements preceding and accompanying the accumulation and departure of the ice-sheet of the Glacial period, deforming the old river valleys and changing them to lakes, as will be presently noted.

It seems to me most likely that the watershed dividing the streams tributary to the Gulf of Mexico from those tributary to the Atlantic ocean and the Gulf of St. Lawrence, which

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*Presented before the Geological Society of America and Section E of the American Association for the Advancement of Science, August, 1896.

now passes around the south and west sides of the Laurentian lakes, extended instead during all the Tertiary era, and in the early Quaternary up to the Ice Age, along the Allegheny mountain belt and directly onward northeasterly to the Adirondacks, turning thence northwesterly across the Ontario highlands east of Georgian bay to the present hight of land north of lake Superior. The preglacial Laurentian river of Spencer, which he supposes to have received the drainage of the present Laurentian lakes area, appears to me more probably to have been limited to head streams which are now represented by lake Champlain, the Ottawa river, and the Saguenay. We certainly owe much to Spencer for his valuable pioneer studies of the preglacial channels of connection between the several Laurentian lake basins; but I believe that the grand topographic features of the region, with our knowledge of the epeirogenic movements ending the Tertiary and bringing in the Quaternary era, should lead us to look for the Tertiary lower course of the river draining the area of the present Laurentian lakes along some route southerly from lake Michigan, rather than either easterly from lake Ontario along the Mohawk valley or northeasterly along the St. Lawrence valley.

Since the elevation of the interior of our continent from its mediterranean Cretaceous sea, and since the approximately contemporaneous uplift of the Jura-Cretaceous or Schooley peneplain, which had occupied the country eastward, so well studied by Davis, Wood, Hershey and others, vast denudation and broad and deep valley erosion have sculptured the Colorado plateaus and cañon, have cut down the surface of the great western plains hundreds and in part thousands of feet, have eroded the broad Appalachian valleys, and have channeled the fjords of Greenland (as is demonstrable notably for the Waigat passage setting off the island of Disco), besides probably also eroding the greater part of the straits, sounds, gulfs and bays of the Arctic archipelago and the Hudson bay region. Amid such stupendous subaërial erosion, the basins of the Laurentian lakes received essentially their present forms, but with continuous and free drainage, as I believe, toward the west and south. A great trunk stream flowing south along the bed of lake Michigan drew its chief tributa

ries on one side from the basins of lakes Huron, Erie, and Ontario, and on the other side from the basin of lake Superior.

Changes bringing on the Ice Age.

When the early Quaternary epeirogenic uplifts heaved the northern half of our continent 2.000 feet to probably in large part 5,000 feet above its present hight, as is known by fjords and the continuations of valleys on the submarine slopes of the continental plateau, it seems not improbable that the warping and deformation of the land surface enclosed and changed into land-locked basins some parts of the Tertiary river valleys of the Laurentian lakes area, so that these lakes may have begun to exist in some form before the Ice Age. About the same time, during the epeirogenic movements which finally brought on the Glacial period, the Ohio river and the upper Mississippi river, as suggested by Chamberlin, Leverett, and Hershey. assumed nearly their present relative importance and have since channeled large valleys, although wholly disproportionate with the great Tertiary valleys which are now the beds of the Laurentian lakes.

At length the high elevation northward caused snowfall to prevail there. instead of rain, during all seasons of the year; and in several or many thousand years it enveloped all the country from the Arctic sea to the Missouri and Ohio rivers, and from the Atlantic to the Pacific, with a thick sheet of snow and ice like the ice-sheets now covering the Antarctic continent and the interior of Greenland.

Recession of the Ice-sheet.

Under the vast weight of the ice accumulation this part of the earth's crust, after bearing the burden for a long time, isostatically sank, so that when the ice-sheet, exposed thereby along its borders to a warm temperate climate, melted away, the land on which it had lain was uncovered with a less altitude than now. The depression of the land beneath the sea, from which it has since risen, extended from Boston and from Nova Scotia, where the relative hights of land and sea were nearly the same as now, inland to a vertical extent of 560 feet at Montreal and 500 to 600 feet thence westerly to the areas of the Laurentian lakes, the glacial lake Agassiz, and the basin of Hudson bay.

Melting on its margin, because of the land depression and restoration of a warm climate, the ice-sheet waned and gradually withdrew, although with many vicissitudes of temporary halts, marked by marginal moraines. Its great readvance after the Aftonian interglacial retreat, however, seems referable to an earlier time while yet the high preglacial altitude continued, though perhaps in a diminished degree.

GLACIAL LAKES IN THE ST. LAWRENCE BASIN.

With the retreat of the continental glacier, all hydrographic basins which had a descent toward the receding ice border were temporarily occupied by glacial lakes, held by the ice barrier until its continued recession gave avenues of discharge and at last permitted drainage to become established in its present courses. Over the great Laurentian lakes, as they exist to-day, such glacial lakes of much larger extent rose to maximum hights from 50 feet to 600 feet above the present lake levels, as shown by the deserted beaches and deltas and by old channels of outflow. More correctly, however, we should say that the lowering of the glacial lakes, by erosion and changes of outlets, to their present representatives, together with the uplifts of the northern and northeastern parts of the old lake basins, as compared with their less uplifted southern portions, have a combined maximum of about 600 feet in each of the three basins of lakes Superior, Huron, and Ontario.

Lake Warren. The first in the order of time, and the largest in area and depth, among the three glacial lakes to be here specially noticed, was lake Warren, so named by Spencer from his exploration of its shores in the basin of lake Erie. Its shore lines, mapped by Spencer, Gilbert, Lawson, Taylor, and others, show that in its maximum extension this glacial lake stretched from the west end of the basin of lake Ontario west and northwest over the four upper great lakes, attaining an area nearly equal to that of the contemporaneous lake Agassiz in the basin of the Red river of the North and of lake Winnipeg. The latest southern beaches of lake Warren, traced by Gilbert eastward to Crittenden, N. Y., are there found by Leverett to have been contemporaneous with the Lockport marginal moraine. The course of the boundary of the retreating ice-sheet at the time of greatest extent of lake

Warren is approximately indicated by the accompanying map

FIG. 1. STAGES OF THE ICE AGE IN THE UNITED STATES AND CANADA. Unglaciated land areas are dotted.

(figure 1), which shows the maximum area of the continental glacier and successive stages of its recession in the United States and southern Canada.

Lake Algonquin. As soon as the glacial recession uncovered the Mohawk valley, the waters of lake Warren, formerly outflowing at Chicago to the Mississippi river, were rapidly drawn away through the Mohawk and Hudson valleys. In the basins of lakes Michigan, Huron, and Superior, comprising the larger part of what had been lake Warren, there remained a similar but restricted body of water, which Spencer has named lake Algonquin, dammed by the lingering ice-sheet only on the part of its border east of Georgian bay, in the region of lake Nipissing and the Mattawa river, and outflowing through the St. Clair river and lake, the Detroit river, and a stream which may be called the river Erie, continuing eastward along the bed of lake Erie to the incipient Niagara river and falls. We shall return in a later part of this paper to further consideration of lake Algonquin and its ice barrier.

Lake Iroquois. In the basin of lake Ontario a glacial lake, also much studied and named lake Iroquois by Spencer, outflowed at Rome, N. Y., to the Mohawk and Hudson. Its surface at Toronto during the early part of its existence coincided nearly with that of the present lake Ontario: but later,

owing to the gradual uplift of the country on the north and east, including the Rome outlet, the western part of lake Iroquois was caused to rise upon its coast to a hight of about 200 feet, finally holding that level during many years, with the formation of the well developed Iroquois beach. The differential epeirogenic movement of the land and the consequent westward rise of the lake, confined by the waning ice-sheet on its northeast side, are known by the northeastward ascent of the old beaches and by drift sections which show two readvances of the ice-front in the vicinity of Toronto during the gradual rise of the lake there, to which reference will be again made on a following page.

Beginning of Niagara River and its Erosion of the Gorge below the Falls.

The departure of the ice-sheet, as we have seen, uncovered the northeastern part of the continent with so low an altitude that the drainage of the Laurentian lakes region then, for the first time, as I believe, began to outflow eastward, earliest by the Hudson, and later, with the farther glacial retreat, by the St. Lawrence. From the day when the Rome avenue of outflow drew down the waters below the Niagara escarpment, which runs between the basins of lakes Erie and Ontario, the Niagara river has been flowing over its falls and has been cutting its gorge backward from the escarpment. At first this river was scarcely separated from the river Erie by any lake in the Erie basin; but gradually the differential uplifting of the land raised the eastern rim of the basin, at Buffalo, to such hight that the extensive but shallow lake Erie covered the former river Erie, and the great level plain through which that river flowed is now the lake bed.

Variations of the Volume of Niagara River.

Gilbert, in his able papers on the history of Niagara river, well reviews its probable changes of volume due to variations of the average yearly rainfall and snowfall, the melting of the ice-sheet during its departure, and other varying conditions. Most of these causes of variation of the river's volume seem to have been not widely different from those of the past thousand years or even of the past century, during which its flow and the rate of erosion of the falls and gorge have been observed. Some of the variations have doubtless tended to

reduce the river and to make it erode more slowly during portions of its history than at present; but other changing conditions have with equal certainty promoted its erosion and so have tended to shorten the time required for the excavation of its gorge. With one exception, the conditions of variability appear to have tended, in the aggregate, to subtract from the time indicated by the present rate of erosion, rather than to add to it.

THE HYPOTHESIS OF THE NIPISSING AND MATTAWA OUTLET FROM LAKES HURON, MICHIGAN AND SUPERIOR.

Among the conditions which have been supposed to cause Niagara river to vary from its present size, only one would produce a great and long continued diminution of the river, so giving for a large part of its history only very slow erosion and recession of the falls. This hypothetical factor in our problem, which has been assumed by Gilbert, Wright, Spencer, and Taylor, to considerably prolong the time of the gorge erosion, is the diversion of the outflow from the three lakes above lake Erie to forsake its present course and pass eastward from Georgian bay by the way of lake Nipissing and the Mattawa river to the Ottawa. On the other hand, Bell and Barlow, of the Canadian Geological Survey, oppose this hypothesis, and state that they find no evidence of a former great river there.

An examination of the relationship of the several glacial lakes in the St. Lawrence basin, and of the approximate outlines of successive stages of retreat of the ice-sheet which was their barrier (as shown in figure 1), convinces me that this Mattawa outlet from lakes Huron, Michigan and Superior was obstructed by the receding ice-front until after the land there had risen from its Late Glacial or Champlain depression to such altitude that the St. Clair and Detroit rivers continued to be constantly the outlet from those lakes, sending their waters to the Niagara river and falls during all their history. Lake Algonquin was at first held on the Mattawa district by an eastern barrier of the waning ice-sheet, as is known by the Nipissing beach far above the present lowest point of the watershed. But differential elevation of the land, as soon as it was unburdened by the glacial retreat, took place here, as on the area of lake Agassiz, while yet the ice barrier remained,

though it was gradually retreating: and in both these great lake basins the uplift was nearly or quite completed during the existence of the glacial lakes. Finally lake Algonquin, by the northeastward land elevation, became divided into its successors, lakes Huron, Michigan, and Superior.

Lakes Algonquin and Iroquois were contemporaneous, and the Ontario basin enclosing lake Iroquois was at the same time uplifted toward the northeast, with inclination of its earlier shore lines, and with gradual rise of the lake surface westward because its outlet, at Rome, was raised much more than the western part of the basin. While these two glacial lakes were undergoing such changes, a lobe of the mainly retreating but wavering ice-sheet lingered on the highlands north of lake Ontario; and twice its moderate readvance was recorded by deposits of till intercalated with the stratified beds of a lacustrine delta in the extensive section of Scarboro' Heights, near Toronto. The uplift of the Iroquois basin, as well as that of the Algonquin basin, is thus shown to have been far advanced and nearly completed during the continuance of their ice barriers; and also thus it is demonstrated either that no outflow from Georgian bay and the upper lakes ever passed to the Mattawa, or that it was of very short duration. The whole time of existence of lake Agassiz, as estimated by comparison of its shore erosion and beach accumulation with those of lake Michigan and others of the Laurentian lakes since the departure of the ice-sheet, appears to have been about 1,000 years. In comparison with this, we may confidently assert that, if any outflow passed for a time over lake Nipissing to the Mattawa river, it could have done so only for a few decades of years.

Duration of Niagara Falls and of the Postglacial Period.

About three-fourths of the period of 32,000 years which Spencer assigns as the age of the Niagara river and falls are derived from this hypothesis of the Mattawa outlet from the upper lakes, which, as I believe, is untenable, or at the most had only a very short existence. Leaving out that element of the problem as insignificant, and dividing the length of the Niagara gorge (about six and a half miles) by the recent rate

of average annual recession of the falls (nearly five feet), we have approximately 7,000 years, as announced by Gilbert at the meeting of the American Association in Buffalo in 1886, as the probable time required for the erosion of the gorge.

This measure, which (not to be too exact in figures depending on somewhat varying conditions of the Niagara history) we may place in round numbers as between 5,000 and 10,000 years, is of great interest to geologists because it is at the same time the duration of the period since the end of the Ice Age, or, speaking more definitely, since the retreat of the continental glacier from the northern United States and southern Canada. It may be so accepted with confidence, for it agrees with the estimates and computations independently made for the same period by Prof. N. H. Winchell, from the recession of the Falls of St. Anthony; by Prof. G. Frederick Wright, from the filling of depressions among kames and eskers, and from erosion by streams tributary to lake Erie; and by Prof. B. K. Emerson, from postglacial deposition in the valley of the Connecticut river. In Europe, likewise, numerous estimates of the lapse of time since the Glacial period, as collated by Hansen, are found to be comprised between the limits of 5,000 and 12,000 years, thus being well harmonious with the measure given us by Niagara falls.

From this unit of measurement and its ratios of comparison with the preceding geologic periods and eras, according to Dana, Walcott, and others, we derive an approximate duration of 100,000 years for the whole Quaternary era; of perhaps 3,000,000 years for the Tertiary era; some ten million years for the Mesozoic era; and probably forty to eighty million years for the Paleozoic era. In total, the time since life began on the earth is thus shown to be probably a hundred million years, compared with which the duration of Niagara, though a hundred times longer than a man's lifetime, seems geologically like a span or a hand's breadth beside the long vista of the past ages.

THE BLACK RIVER LIMESTONE AT LAKE NIPISSING.

By N. H. Winchell.

On the occasion of the meeting of the American Association for the Advancement of Science at Toronto in 1889 an excursion was made to the region of lake Nipissing, which was attended by the writer. Subsequently a small collection of fossils from the islands of this lake was procured through the aid of Mr. T. D. Ledyard, esq., of Toronto. They were put in the possession of Mr. Ulrich, Newport, Ky., who has recently furnished the following identifications.

The islands of lake Nipissing are briefly described by Alexander Murray in his geological report for 1854, and the islands themselves are represented on his map accompanying his report, sheets 8 and 10. This limestone is found on one of the islands of the Manitou group, in the east-central portion of the lake, and on Iron island, in the western portion, and it probably underlies much of the lake between. On the Manitou island it rests unconformably on gneiss and trap rock, which constitute the larger portion of the island, showing a thickness of over six feet, in the lower portion being a siliceous limestone * * * "holding Orthoceras, with a few other obscure fossils and small angular fragments of the altered rock on which it rests. Over the siliceous bed are alternations of blue and gray limestone and shale, holding numerous fossils, among which are orthoceratites and shells, both univalve and bivalve, but all too obscurely defined to admit of correct identification: the orthoceratites, which are very numerous in all the beds, strongly resemble the *Ormoceras tenuifilum* of Hall, given by that author as a characteristic species of the Black River formation. These beds occur on the S. W. end of the island and show a gentle dip toward the S. W.

On the west side of Iron island beds of red and gray sandstone rest unconformably on gneiss and crystalline limestone, dipping at the north end of the exposure S. 30° W. <4°, and at the south end S. 75° W. <3° to 5°. The lowest beds of the sandstone are red, with small round green spots occasionally dotted over the surface; the sandstones are coarse grained and the beds vary in thickness from six inches to two feet. The upper beds are yellowish-gray and sometimes whitish, and occasionally appear to be slightly calcareous. They are mostly of coarse grain, at times becoming a fine conglomerate. Small subspherical concretions are common to the upper beds, and on one occasion an impression resembling the obscure coat of an orthoceratite was observed on an exposed surface. Some of the beds are probably well adapted for grindstones.

The greatest thickness exposed on the beach is from ten to twelve feet, but the side of the hill facing the west, which was about seventy feet or upwards over the level of the lake, is chiefly of sandstone, some of which may be additional strata. Large angular masses of fossiliferous limestone are strewn over the beach, having been removed apparently no great distance from their parent beds. They probably occupy a portion of the bottom of the lake. The character of the fossils in these masses appeared to be of the Chazy age."—*Murray*.

Ormoceras tenuifilicus Hall. Separated fragment of siphuncle and section with septa; ill preserved.

Escharopora subrecta Ulr.

Helopora mucronata Ulr. (Stones River group species).

Escharopora ? limitaris Ulr.

Rhinidictya mutabilis var. *major* Ulr.

Phyllodictya varia Ulr.

Batostoma winchelli Ulr.

Callopora multitabulata Ulr.

Columns of an undetermined *Glyptocrinus*.

Rhynchotrema inæquivalvis Castenau.

Leperditia fabulites Con ?

Aparchites neglectus Ulr.

These species indicate exact equivalence with the Black River group of shales at Minneapolis, as discussed and defined in Vol. III, Part 2. of the forthcoming report of the Minnesota survey. They show the probable former prevalence of the Trenton ocean far to the north and taken in connection with the small known area of the Trenton in northern Michigan, near the base of Keweenaw point, indicate that in the Trenton age a continuous sea occupied the area from lake Nipissing to lake Winnipeg.

EDITORIAL COMMENT.

THE MISSING LINK.

The gap which separates man from the ape is simiiar to and perhaps no greater than other gaps existing betwen extinct forms of animal life which have been bridged by the easy assumption of specific variation and direct genetic descent, without doing violence to the theory of evolution by natural selection. But between the ape and man there is a chasm, other than morphological, which presents a barrier against the operation of the law of evolution, and which it seems to be necessary to fill by more gradual steps before the

"descent of man" will be acceptable to the average philosopher. Hence, every variation in the human skeleton which tends, on good authority, to obliterate the distinction between man and the other Primates has been scrutinized by the most searching comparisons and in several instances the intermediate forms have been announced. On making more profound study, however, such discoveries have failed to stand the test and have been assigned at last to some of the savage types of the human family as now known. At the present time not one of these varietal forms can be said to occupy the intermediate position between man and the ape, on the evidence and authority of the most expert anthropologists.

The Homo neanderthalensis, of King, subjected to a comparison with Australian aborigines by Huxley, was considered by him in no sense intermediate between man and the apes. According to his view this skull resembled the crania of the people of Denmark during the stone period: and according to Sir William Turner it was closely paralleled by skulls of existing savage races and even by occasional specimens of modern European crania. This conclusion is now generally accepted by anthropologists. The neanderthaloid characters are found to be not uncommon among the crania of savage as well as civilized races.

The "man of Spy" made his debut in 1886. His sponsors, MM. Fraipont and Lohest, classed him with the man of the Neander valley. The antero-posterior curvature of the condyles of the femur and the modification of the head of the tibia of the man of Spy were characters which indicated a less erect position than man assumes at the present time. It has since been pointed out, however, by Prof. Arthur Thomson and by Prof. Manouvier, that the squatting habit, and other attitudes habitually assumed by savage man, operate powerfully in modifying the articular areas of some of the great bones of the skeleton and particularly of the tibia, the femur and the pelvis. The head of the tibia by this means is subject to great retroversion. This is seen in the tibiæ of neolithic men, in some modern Parisians and most of all in certain Indians of California. It is evident, therefore, that this peculiarity is by no means characteristically simian, and the man of Spy retains his place alongside of the really human forms of the genus Homo.

Last of all, Pitheccanthropus erectus has appeared, from Java. Dr. Eugene Dubois has given the details of the discovery and an elaborate description of his anthropoid features. His descriptions and conclusions have been widely published and have met with cautious and partial acceptance.

The materials on which Dr. Dubois bases his conclusions consist of a skull, a tooth and a femur. The skull is intermediate in size, between the average gorilla and civilized man, but when compared with the average skull of savage man, as has been done by Sir Wm. Turner,* who assumes the Australian as a fair example of the modern savage, the fossil skull falls but little below the average of the male and exceeds the size of the female. Skulls of other savage races, such as those of the Andaman islanders, Admiralty islanders, Bush people, Veddahs and hill tribes of India, range about the same in size as the skull from Java.

The third upper molar tooth was not immediately connected with the skull, but was found at a distance of one metre from it and the femur at a distance of fifteen metres. The remains may have resulted from different individuals, and in the opinion of Prof. Turner the tooth has strong evidence of not being human, but rather the tooth of an orang, which still inhabits Borneo and Sumatra.

As to the femur, while exhibiting some peculiarities by which it departs from the normal human femur, and assumes characters which, in the opinion of Dr. Dubois, mark it as derivable from the anthropoid apes, yet it is also found, by comparison with a large number of human femora, that, according to Prof. Turner, the same peculiarities are occasionally met with, and hence they lose their value as criteria for differentiating this bone from human remains At best, this femur is assignable to the Neanderthal race, which by all is considered of human and not of simian type. It should be remarked also that the distance which separated the femur from the skull, and the comparative freshness of the former, render it extremely improbable that they came from the same skeleton.

Hypothesis, therefore, and hypothesis only, supports as yet the derivation of man from the ape. N. H. W.

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*Proceedings of the Royal Society of Edinburgh, vol. xx.

THE LAW OF PRIORITY.

J. T. Cunningham, M. A., declares that the law of priority in zoological nomenclature is a dead failure (*Natural Science*, May, 1896). Perturbation in England upon the question of whether it is or not is at present very deep, but to an American paleontologist such a declaration as the above seems outright sedition, or, if not that, to evince, at least, a pathologic condition among nomenclators, for it is quite evident that this law once set aside nothing can result but anarchy and chaos. Admitted that the action of the law may work a percentage of injustice, it is a mere soupçon compared with its righteous consideration of authors and the comfortable sense of peace it brings to its adherents. And what has Mr. Cunningham to offer as its substitute? Nothing; for there is nothing. To go back to the very same raw and disordered methods which precipitated the law of priority, to use names as suits the fancy, or those which have no other claim than currency, this is certainly laying up wrath against the day of wrath. The best paleontologic work of late years in this country shows that American workers abide by the injunctions of this law with a fervent devotion and are hence a peaceable and happy community. J. M. C.

DAS THIERREICH.

It has been suggested that the German Zoological Society, which has undertaken to prepare, under the direction of Prof. F. E. Schulze, a description of every species of living animal, "Das Thierreich," append thereto an account of all extinct species. A writer in *Natural Science* has calculated that "Das Thierreich," if carried out in accordance with its present plan, will contain 128,700 pages and, without binding, make a row of books upward of 40 feet in length. An equally complete paleontological appendix would add a few yards to the length of the work, but is not an impossible task in spite of the imperfections of fossils. Such a realization of Neumayr's dream would be of immense value to students. J. M. C.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Bulletins of American Paleontology, Vol. I, No. 4. The Midway Stage. By G. D. HARRIS. 8vo, 156 pp., 17 plates. Ithaca, June 11, 1896. This important monograph of the lowest stage of the southern Eocene and its fauna is largely based on the personal observations and collections of professor Harris, over almost the entire area in which the horizon is known to occur. The author has also made good use of the results of previous workers in the same field, and has studied their type collections so far as they are now available.

After a brief historical sketch of the subject, the Midway stage is defined and reasons are given for adopting this name rather than one of the numerous synonyms that are listed in full. The classification of the Eocene adopted is as follows:

EOCENE SERIES	6. Vicksburg stage, 5. Jackson stage, 4. Claiborne stage, 3. Lower Claiborne stage, 2. Lignite stage, 1. Midway stage.

The Midway is made to include the Matthew's Landing and Black Bluff clays of Smith and Johnson. As thus defined, it is about 200 feet thick, and it contains the oldest marine Eocene fauna of the Gulf Border region. "Lithologically the Midway beds are subject to rapid changes. We have seen a firm limestone grade out laterally, within a few yards, into an incoherent sand. What is black clay on one river is often represented by calcareous layers on another; but upon the whole, the lower beds of the stage are sandy, clayey and calcareous, while the upper are generally clayey."

This horizon has been recognized by its fossils, at many localities, in a zone immediately above the uppermost Cretaceous beds extending from the Rio Grande, some distance above Laredo, through Texas, Arkansas, Tennessee, Mississippi and Alabama, to Fort Gaines, Georgia, on the Chattahooche river. As might be expected, the fauna collected from such a long coast line shows some variation, and this is especially noticeable in the Chattahooche section, where the beds are mostly calcareous. Professor Harris is probably right in attributing these variations to differences in the character of the sea bottom. Similar variations in the sediments and life of the upper Cretaceous of the same region have been noticed, though in this case the calcareous elements are nearly absent on the Chattahooche and rapidly thicken westward in Alabama and Mississippi.

The most important stratigraphic fact recorded is the discovery that the basal Eocene of the southern states is not conformable on the upper Cretaceous, but the contact gives evidence at many places that there was an erosion interval between them. This is shown by an irregular surface, by lines of pebbles, and by the occurrence of rolled fragments

of Cretaceous fossils in the lowest layer of the Eocene. A similar case of redeposited Cretaceous fossils in the Eocene has been recorded from the neighborhood of Wilmington, N. C., but the exact horizons involved were not determined with sufficient accuracy to permit its use as evidence of a general non-conformity. The complete change in the marine invertebrate fauna, in passing from the latest Cretaceous to the Eocene, which is only emphasized by the present work in which every known species from the lowest Eocene stage is figured, has long caused paleontologists to believe that there could not have been continuous deposition from the one to the other, but the horizontal position and similarity of the beds has made the recognition of the stratigraphic break difficult, especially when, as at Prairie Bluff, Alabama, 100 feet of the Eocene has usually been assigned to the Cretaceous and the contact has consequently been sought at the wrong horizon.

No exact correlation is attempted with the Eocene of Europe, though the author states that there is a general similarity of faunas, usually without specific identity, in the basal Eocene of the two regions. The Midway fauna is more closely related to the fauna of Maria Farina, Brazil, which was described as Cretaceous, but is referred to the Eocene by professor Harris. Whether the Brazilian fossils are Eocene or not, the fauna of about 140 molluscan species described and figured in the body of this work are unquestionably Eocene and show but slight relationship with our latest Cretaceous fauna. So far as known they have not a single species in common.

Lack of space forbids a detailed review of the biological features of the Midway fauna. Of special interest are the first record of the occurrence of *Reilostoma* and *Perna* in the American Eocene, and the extension of the range of the Nautiloid genus *Enclimatoceras* through the whole thickness of the Midway beds. The reviewer has collected a similar species of *Perna* in the lowest Eocene beds of California.

Three other important papers, by Prof. Harris and Mr. T. H. Aldrich, on Tertiary faunas have already appeared in this series of bulletins and the gratifying announcement is made that the present monograph is to be followed by similar ones on the other Eocene faunas.

Attention should be called to the omission of an index, which in a work of this kind, treating so many species, is a serious matter to the busy worker. It is doubtless the intention to index the whole volume of which this forms a part, but such large paleontological papers, complete in themselves, should be indexed independently. For similar reasons, as well as to improve the appearance of the page, it would be better to use a greater variety of type in the descriptions of the species, especially in the headings. T. W. S.

The Fauna of the Magnesian Series. F. W. SARDESON. (Bull. Minn. Acad. Nat. Sci., vol. IV, no. 1, pp. 92-105, plates 5 and 6, 1896.) This paper consists chiefly of a succession of very brief notes and descriptions of twenty-nine species (two trilobites, five brachiopoda, seventeen gastropoda and five cephalopoda—eighteen of them new) which have been ob-

served by Mr. Sardeson in the Shakopee, Oneota, Jordan and Saint Lawrence formations of Minnesota and Wisconsin. These notes are preceded and followed by four and one-half pages of matter devoted to subjects as follows: (1) A statement of the object of the paper; (2) an enumeration of the lithological divisions of the "Lower Magnesian" and "Potsdam" of the upper Mississippi basin; (3) general remarks on their faunas, in which the author expresses the opinion that the "Shakopee is faunally separate from the Saint Peter above and to a less degree also from the Oneota below," and that the Oneota, Jordan and Saint Lawrence formations are closely related to each other and faunally distinct from the St. Croix sandstone beneath them; (4) remarks on preservation of fossils: (5) table showing vertical range of species: (6) list of and critical remarks on Lower Magnesian species described from Iowa by professor Calvin: (7) list of Lower Magnesian fossils described by Whitfield and A. Winchell and remarks on the same; (8) a statement to the effect that the Shakopee fauna is most like that of the "Upper Calciferous," while "that of Oneota, Jordan and St. Lawrence is likewise comparable to the Lower Calciferous of New York;" and, finally, (9) a paragraph devoted to the "biological side of the question," in which we find the very true observation that "to associate the species *Raphistoma leiosomellum*, *R. lewistonense*, *R. minnesotense* and *R. oweni* is to extend the limits of the genus." From the table showing vertical range of species we learn, and this is perhaps the most important fact established in this paper, that all of the seven species found in the Shakopee are restricted to that formation, while of sixteen species found in the Oneota, five occur also in one or both of the two formations immediately beneath.

Concerning the various species, especially the Gastropoda, many of which are represented in the reviewer's cabinet, we are led to remark that Mr. Sardeson seems to have had anything but a clear conception of their generic affinities. His descriptions of new species also, considering the poor character of the illustrations, are too brief and quite devoid of anything like comparisons with previously known forms. Evidently he proceeded to name his fossils without comparing them with species described from equivalent rocks in other regions. Naturally such work is very liable to swell the list of synonyms and it will be extraordinary indeed if Mr. Sardeson escapes entirely the responsibility of having proposed one or more unnecessary names in the paper under discussion. One already is evident in his *Murchisonia argylensis*, which, with good specimens before us, we do not hesitate to pronounce the same as *M. anna* Billings. The apical angle of this shell is given by Mr. Sardeson as 160°. It should be 15° or 16°. We assure him also that the band is not central but lies in the lower third a short distance above the suture.

The carina or angle forming the lower boundary of the flattened outer face of the whorls of his *Helicotoma* (?) *peccatonica*, as well as the shape of the shell in general, is indicative of *Trochonema* and not *Helicotoma*. The species seems to be related to *T. exile* Whitfield. His *Raphistoma lewistonense*, on the other hand, should have been referred

to *Helicotoma*. *Ophileta alturensis*, *Raphistoma minnesotense* and *R. oweni* are doubtless congeneric, and if one is an *Ophileta* the other two are also. Whatever position they may occupy ultimately it is certain that they are quite distinct from *Raphistoma*. Of the five species referred to the latter genus by Mr. Sardeson, only one, *R. rudum*, probably belongs here. The *Straparollus intralobatus* we would call an *Eccyliomphalus* with contiguous whorls. *Subulites exactus* should have been compared with *S. calciferus* Billings. Like that species, it is a *Fusispira* and not a *Subulites*. E. O. U.

The Fauna of the Cambrian of Tejrovic and Skrej in Bohemia. By J. F. POMPECKJ. (Jahrbuch der k. k. geol., Reichsanstalt, 1895, 45 Band, 3 Haft.) We owe to Dr. Pompeckj's pen a very full and lucid account of the Cambrian strata and fossils of the above localities in Bohemia. The clay slates of the Paradoxides beds pass downward, after the intervention of a sandstone bed and felsites, into conglomerates and sandstones, in the lower part of which another Cambrian fauna has been detected. These rest upon porphyry and diabase which overlie graphitic clay-slate, the true Etage "B."

It would seem from this essay that a part of Barrande's Etage B is to be referred to the Cambrian, there being a discordance in this stage, and the upper part containing a Cambrian fauna.

The Etage C has been divided by the Bohemian geologists, who find two subfaunas of Paradoxides, the upper of which is the primordial fauna as known to Barrande [though he was acquainted with a number of species that come from the lower subfauna]. The lower subfauna contains *Paradoxides rugulosus*, the upper *P. bohemicus* (cf *P. tissini*).

A Lower Cambrian fauna is referred to the Olenellus grouping, though the genus has not been recovered from it, but the crustaceans that do occur are of different species from those of the Paradoxides beds above and some genera are different.

A full description of these faunas is given by Dr. Pompeckj, and a number of new species are described.

The cystidians are well represented and a new genus, *Stromato cystites*, is described.

The brachiopods are represented by four genera: the *Obolus* (?) *bohemicus* of Barrande is referred to *Acrothele* and another species of this genus described.* A minute species of Acrotreta, near *A. socialis* v. Seebach, is described, and a Lingulella. Two species of Orthis, one of the "Middle Cambrian" (Paradoxides bed) *O. romingeri* Barr.,† the other in several varieties from the Lower Cambrian (Olenellus zone).

Five species and one variety of Agnostus are cited; the species were described by Barrande.

The species of Paradoxides and Hydrocephalus were described by Boeck, Corda and Barrande, except one, which is claimed as new (*P. jahni*): this species is quite like *Hydrocephalus saturnoides* Barr. Dr.

*Compare this with *A. matthewi* var. *costata*. See "Protolenus fauna."
†Compare with *O.* (*Protorthis*) *quacoensis*. Trans. Roy. Soc., vol. III.

Pompeckj, therefore, appears to assign *Hydrocephalus* as a subgenus of Paradoxides.

Under the Olenidæ he includes Conocoryphe, Ctenocephalus, Conocephalites, Ptychoparia, Solenopleura, Agraulos, Ellipsocephalus, Protypus and Sao. In addition to a number of well known species of Barrande and Emmrich, Dr. Pompeckj describes some new forms from the Paradoxides beds--a variety of *Ptychoparia striata* and one of *Agnostus integer* Barr. But the most notable additions are in the fauna of the Olenellus zone, Lower Cambrian, consisting of a Protypus (?), an Ellipocephalus, two Solmopleura (one species referred doubtfully), an Agraulos and two species of Ptychoparia. The Protypus is defective and doubtfully referred. In the long glabellas of some species and the continuous sylobes of others the fauna shows relations to that of Protoleus, but all the species and several genera are different.

A portion of the memoir is given to a comparison of the fauna of the Lower Cambrian with the corresponding faunas of other regions, especially of Great Britain, Scandinavia, Estland (Russia) and Sardinia. Another part of the work is given to an analysis of the fauna of the Bohemian Paradoxides beds and a comparison with those of other countries- Great Britain, Scandinavia, France, Spain.

The memoir is accompanied by five excellent plates of the species found at Tejrovic and Skrej. G. F. M.

Geological Survey of New Jersey, Annual Report for the year 1895. JOHN C. SMOCK, State Geologist. (Pages xl, 198, with seven plates and nine figures in the text. Trenton. N. J., 1896.) The administrative report of the State Geologist comprises 24 pages, in which the work during the past year in all the branches of the survey is concisely reviewed. Four reports, with more full details, are given, the first being by Prof. ROLLIN D. SALISBURY, on the surface geology; the second by Dr. J. E. WOLFF and LEWIS G. WESTGATE, on the Archean geology of the Highlands in northern New Jersey, and especially of the northern part of Jenny Jump mountain, in Warren county; the third by LEWIS WOOLMAN, on artesian wells in southern New Jersey; and the fourth by C. C. VERMEULE, JOHN GIFFORD, and GIFFORD PINCHOT, on the forests of the State.

The report of Prof. Salisbury, who was assisted by G. N. Knapp, gives considerable descriptions of the Beacon Hill, Pensauken, and Jamesburg formations, which were formerly classed together as the "Yellow gravel." The first of these three divisions is referred to the Miocene period, and the second to the Lafayette period (according to the last preceding annual report of this survey), while a part of the third, in its latest and topographically lowest development, is found to be equivalent with the "low-level Columbia" formation of the states southward and with the Trenton gravel of the Delaware valley. A map shows the scatte red areas where the Pensauken or Lafayette formation has been spared by subaerial erosion, stretching across the state from Salem county, opposite to Wilmington, Del., northeastward to the Raritan river between New Brunswick and Perth Amboy. Continuing eastward from

the southern part of this belt, it is probable that Pensauken beds are thinly spread on the surface, or that they underlie the shallow Jamesburg sand deposits, throughout all southeastern New Jersey.

Mr. Westgate, from his careful mapping of the metamorphic gneiss and limestone belts of Jenny Jump mountain, concludes that the white crystalline limestones there found are distinct from and older than the blue crystalline limestone, of Cambrian age, which occurs along the northwestern side of the New Jersey Highlands. This is the view which has been generally held, but it has been called in question by Mr. F. L. Nason and others, with arguments for the derivation of the white limestones from the blue through metamorphism. W. U.

Evidences of Glacial Action in Australia in Permo-Carboniferous Time. By T. W. EDGEWORTH DAVID, Professor of Geology in the University of Sydney. (Quart. Journ. Geol. Soc., London, vol. LII, pp. 289-301, read Feb. 5, 1896, with sections and a figure of a glaciated boulder, reduced from a photograph.) This paper reviews the work done by previous observers in tracing the extent of the Permo-Carboniferous glacial deposits of Australia and Tasmania, and, after stating the latest observations by the author, correlates these deposits with the similar and at least approximately contemporaneous glacial formations of southern Africa and India. It is also noted that possibly the lands now represented by South America were likewise glaciated at the same time, according to discoveries by Derby in southern Brazil. In the AM. GEOLOGIST for May, 1889 (vol. III. pp. 299-330), an excellent discussion of this Late Carboniferous or Permian glacial period was given by David White, with discussion of the relations of the Glossopteris flora. Like the Quaternary glacial period, that near the end of the Paleozoic era seems to have prevailed in both the northern and southern circumpolar regions, if, as seems most probable, the ancient glaciated rocks found by Dr. Reusch (AM. GEOLOGIST, vol. VII, p. 388; June, 1891), on the Varanger fjord, in northern Norway, are of the same age.

The Australian glacial beds originally had a great areal extent, and at Bacchus Marsh, in Victoria, they present a thickness of about 2,000 feet, belonging to a succession of many glacial and interglacial stages. Nine or ten distinct boulder-bearing horizons are there separated one from another by thick deposits of sandstone and conglomerate. Another district, in New South Wales, displays "a group of coal measures, over 230 feet thick, and comprising from 20 to 40 feet in thickness of coal," between two horizons of marine beds enclosing ice-borne boulders. In the several districts where striated rock-pavements are found, showing the direction of the drift transportation, it was from south to north. The plentiful occurrence of striated boulders leaves no doubt that they were supplied by glaciers or ice-sheets. W. U.

The Straining of the Earth under Secular Cooling. By C. DAVISON. (Phil. Mag., Feb'y, 1896.) In this article, which is substantially a new edition of the same author's paper read before the Royal Society in Feb'y, 1894, Mr. Davison gives his latest deduction on the subject of

the "layer of no strain." Estimates published a few years ago when the topic was first discussed placed this stratum at a depth of about two miles below the surface. But it was pointed out at the time that so small a depth could not be sufficient, because many cases were known in which strata have been brought to the surface by folding from far greater depths. This is the case, for instance, in the Appalachians, where rocks that were once covered with eight miles of other beds are exposed to the day.

Mr. Davison says, "Estimates of the depth of the surface of no strain have hitherto been founded on the assumptions that the conductivity and coefficient of dilatation are constant." But taking the other datum that these factors increase with the temperature and following out the calculation, Mr. Davison comes to the conclusion that with an initial temperature of 7,000° and a period of 100,000,000 years the level of no strain would be at the depth of nearly 8 miles. Evidently, however, even this increased depth will fail to satisfy the physical geologist, as shown above. Mr. Davison, however, says, "The numerical results here obtained cannot be regarded as reliable. They are given for their qualitative rather than their quantitative value," and concludes thus, "If we regard the contraction theory as a theory of the formation of mountain ranges only and not necessarily of the continental masses, we may, I think, conclude that calculations as to its alleged insufficiency are at present inadmissible." E. W. C.

The Great Valley of California: a Criticism of the Theory of Isostasy. By F. LESLIE RANSOME. (University of California, Bulletin of the Department of Geology, vol. I, pp. 371-428, Berkeley, Cal., May, 1896. Price, 45 cents.) The valley plain of the Sacramento and San Joaquin rivers, with its continuation in the area of interior drainage tributary to Tulare lake, has a length of about 400 miles and an average width of 50 miles, giving it an area of 20,000 square miles. Excepting at San Francisco bay, this lowland plain is entirely enclosed by mountains, its eastern and western boundaries being respectively the Sierra Nevada and Coast ranges. It dates from the time of great orogenic disturbance at the close of the Miocene period, by which the Coast ranges were first uplifted as a connected mountain chain; but the principal topographic features may be said to have their origin in the long subsequent Early Quaternary faulting and westward tilting of the Sierra Nevada belt, raising its eastern border to its present great hight, while at the same time the Coast mountains were again greatly uplifted. But these orogenic movements on both sides of the valley plain have been also continued, as the author affirms, during the Pleistocene period, with their antithesis in the progressive subsidence of the intermediate valley belt, upon which Quaternary sediments from the waste of the mountains have been deposited to a maximum thickness exceeding 2,000 feet. The relationship between the sedimentation and the subsidence is shown to be discordant with the theory of isostasy, as applied to such restricted areas of the earth's crust, though perhaps not opposed to its application to continents and ocean basins. W. U.

The National Cyclopædia of American Biography. (New York: James T. White & Co., 1893-96.) In the six volumes, each containing about 530 pages, already published of this work, biographical sketches, with portraits, of many geologists and paleontologists of the past and present time are found, including Louis and Alexander Agassiz, George H. Cook, James D. and E. S. Dana, Amos Eaton, Persifor Frazer, Arnold Hague, James Hall, Edward Hitchcock, T. Sterry Hunt, Alpheus Hyatt, Charles T. Jackson, Joseph Leidy, Henry Carvill Lewis, J. W. Powell, Raphael Pumpelly, Samuel H. Scudder, Eugene A. Smith, Charles A. White, Alexander Winchell, and Amos H. Worthen. It is planned to continue the work to a total of twelve volumes. W. U.

Sur un Cristal de Labrador du Gabbro de Minnesota. By N. H. WINCHELL. (Bull. d. l. Soc. Franc. d. Min., t. 19, pp. 90-92, 1896.) A huge porphyritic crystal of plagioclase from the anorthosyte of Beaver Bay, on the north shore of lake Superior, is described and figured. This crystal is the largest porphyritic labradorite, on which good crystal faces occur, that has been recorded. It is a Carlsbad twin of tabular form and is 67.2 mm. across and 15.25 mm. in thickness. The forms which occur are listed and an analysis is given, which shows the feldspar to be between $Ab_1 An_2$ and $Ab_1 An_3$ or labradorite-bytownite.

U. S. G.

RECENT PUBLICATIONS.

I. *Government and State Reports.*

15th (1893-'94) Ann. Rept. U. S. Geol. Surv., xiv and 755 pp., 48 pls., 1895. Preliminary paper on the geology of the common roads of the United States, N. S. Shaler: The Potomac formation, L. F. Ward: Sketch of the geology of the San Francisco peninsula, A. C. Lawson; Preliminary report on the Marquette iron-bearing district of Michigan, C. R. Van Hise and W. S. Bayley, with a chapter on the Republic trough, H. L. Smyth; The origin and relations of central Maryland granites, C. R. Keyes: with an introduction on the general relations of the granitic rocks in the middle Atlantic Piedmont plateau, G. H. Williams.

Ann. Rept. New Jersey Geol. Surv. for 1895, xl and 198 pp., 7 pls., 1896. On caswellite, an altered biotite from Franklin Furnace, N. J., A. H. Chester: Surface geology report of progress, R. D. Salisbury; Report on Archean geology, J. E. Wolff; The geology of the northern part of Jenny Jump mountain, in Warren county, N. J., L. G. Westgate; Report on artesian wells in southern New Jersey, Lewis Woolman.

Ill. State Mus. Nat. Hist., bull. 10, 91 pp., 5 pls., July 10, 1896. Some new species of Echinodermata and a new crustacean from the Palæozoic rocks, S. A. Miller and W. F. E. Gurley.

II. *Proceedings of Scientific Societies.*

Trans. Wagner Free Inst. of Sci., vol. 4, xiv and 61 pp., 19 pls., Jan., 1896. Fossil vertebrates from the Alachua clays of Florida, Joseph Leidy (edited by F. A. Lucas).

Proc. A. A. A. S., 44th meeting (Springfield, Mass., 1895), cxix and 414 pp., Salem, 1896. Contains the following abstracts of papers relating to geology: Gotham's cove, or fractured rocks in northern Vermont, C. H. Hitchcock; Recent discovery of the occurrence of marine Cretaceous strata on Long island, Arthur Hollick; The relations of primary and secondary structures in rocks, C. R. Van Hise; Geological notes on the isles of Shoals, H. C. Hovey; Subdivisions of the Upper Silurian in northeastern Iowa, A. G. Wilson; Supplementary notes on the metamorphic series of the Shasta region of California, J. P. Smith; The great falls of the Mohawk at Cohoes, N. Y., W. H. C. Pynchon; Geological canals between the Atlantic and Pacific oceans, J. W. Spencer; Recent elevation of New England, J. W. Spencer; View of the Ice age as two epochs, the Glacial and Champlain, Warren Upham; Terminology proposed for description of the shell in Pelecypoda, Alpheus Hyatt; A resurvey of the whirlpool and vicinity of the Niagara river, with a demonstration of the true geology of the locality, G. W. Holley; Glacial phenomena between lake Champlain and lake George and the Hudson, G. F. Wright; The Archean and Cambrian rocks of the Green Mountain range in southern Massachusetts, B. K. Emerson; The geology of Worcester county, Mass., B. K. Emerson; Interesting features in the surface geology of the Genesee region, New York, H. L. Fairchild; Distribution of sharks in the Cretaceous, C. R. Eastman; Account of the discovery of a chipped chert implement in undisturbed glacial gravel near Steubenville, Ohio, G. F. Wright.

Proc. and Trans. Nova Scotian Inst. of Sci., vol. 9 (2nd ser. vol. 2), pt. 1, 1896. Notes on concretions found in Canadian rocks, T. C. Weston; The iron ores of Nictaux, N. S., and notes on steel making in Nova Scotia, E. Gilpin, Jr.; A foraminiferous deposit from the bottom of the north Atlantic, A. H. Mackay; Notes on the geology and botany of Digby Neck, L. W. Bailey.

Trans. Kansas Acad. Sci., vol. 14, 370 pp., Topeka, 1896. On the analysis of the deposit from a chalybeate water, E. C. Case; On the constitution of a natural oil from Wilson Co., Kans., F. B. Davis; A dying river, J. R. Mead; The Topeka coal hole, B. B. Smyth; Coal in Atchison Co., Kans., E. B. Knerr; Rock exposures about Atchison, J. M. Price, Jr.; The terminal boulder belt in Shawnee Co., B. B. Smyth; On the eastern extension of the Cretaceous rocks in Kansas and the formation of certain sandhills, Robert Hay; The river counties of Kansas- some notes on their geology and mineral resources, Robert Hay; A bibliography of Kansas geology with some annotations, Robert Hay.

Annals N. Y. Acad. Sci., vol. 9, Nos. 1-2, June, 1896. The monoclinic pyroxenes of New York state, Heinrich Reis.

III. Papers in Scientific Journals.

Science, June 5. On the detection of glacial striæ in reflected light, F. C. Schrader; Occurrence of uintaite in Utah, G. H. Eldridge.

Science, June 12. The Smeeth separating apparatus, J. S. Diller; Current notes on physiography, W. M. Davis; Variations of glaciers, H. F. Reid.

Science, June 26. Fishes, living and fossil, Theo. Gill; Current notes on physiography, W. M. Davis.

Science, July 3. The Lacoe collection in the National Museum, G. B. Goode; Note on the Devonian Palæospondylus, Theo. Gill.

Science, July 10. Work of the United States Geological Survey for the fiscal year 1896-97, W. F. Morsell; Current notes on physiography, W. M. Davis.

Science, July 17. A central Wisconsin baselevel, C. R. Van Hise.

Science, July 24. Recent hydrographic examinations in the Appalachian area, C. C. Babb; Current notes on physiography, W. M. Davis.

Nat. Geographic Mag., June. The Seine, the Meuse and the Moselle, W. M. Davis.

Journ. of Geol., May-June. Classification of marine Trias, J. P. Smith; The geology of the Little Rocky mountains, W. H. Weed and L. V. Pirsson; Schistosity and slaty cleavage, G. F. Becker; Deformation of rocks, III, C. R. Van Hise; Large scale maps as geographical illustrations, W. M. Davis.

Am. Jour. Sci., July. Observation on percussion figures on cleavage plates of mica, T. L. Walker; Pearceite, a sulpharsenite of silver, and on the crystallization of polybasite, S. L. Penfield; Hydrology of the Mississippi, J. L. Greenleaf; Preliminary note on the relation of certain body-plates in the dinichthyids, C. R. Eastman; Tertiary floras of the Yellowstone National park, F. C. Knowlton; New belodont reptile (Stegomus) from the Connecticut River sandstone, O. C. Marsh; Separation and its bearing on geology and zoögeography, A. E. Ortmann.

Am. Jour. Sci., Aug. Geologic efficacy of alkali carbonate solution, E. W. Hilgard; Northupite, pirssonite, a new mineral, gaylussite and hanksite from Borax lake, San Bernardino Co., Cal., J. H. Pratt; Bearpaw mountains of Montana, second paper, W. H. Weed and L. V. Pirsson; Composition and structure of the Hamblen Co., Tenn., meteorite, G. P. Merrill; Wardite, a new hydrous basic phosphate of alumina, J. M. Davison.

Appletons' Pop. Sci. Month., July. Causes, stages, and time of the Ice age, Warren Upham.

Same, Aug. The stone forests of Florissant, A. Heilprin; Sketch of W. W. Mather, with portrait.

Technology Quart., March. The sea mills of Cephalonia, F. W. Crosby and W. O. Crosby.

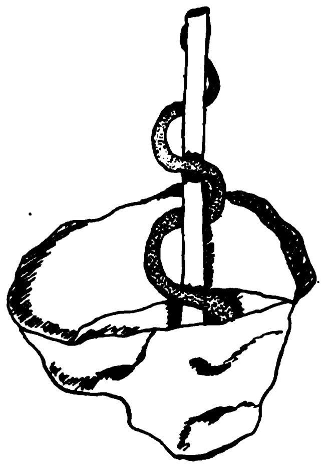
Kansas Univ. Quart., July. Hoplophoneus occidentalis, E. S. Riggs; On the dermal coverings of Hesperornis, S. W. Williston.

Terrestrial Magnetism, July. A summary of the results of the recent magnetic survey of Great Britain and Ireland conducted by Profs. Rücker and Thorpe (contains a chapter on the relation between the magnetic and the geological constitution of Great Britain and Ireland), A. W. Rücker.

CORRESPONDENCE.

An Ally of Daimonelix. In a paper published in the Geologist for June, 1895,* I called attention to the peculiar genus *Daimonelix* from Nebraska and some allied fossils from New York and Switzerland. These were the coiled "fucoid" known as *Spirophyton*, and certain fossil "screw stones" described by Oswald Heer. While the actual position of the fossils in classification remains unsettled it is at the same time interesting to record any similar remains.

On a visit to the geological department of the British Museum last March I was attracted by a specimen in one of the cases, a figure of which I subjoin. It was a mass of flint that had been broken and in the



Flint stone in the British Museum with a coiled fossil.

interior of which was an upright stem with something coiled about it. It bore the label, "Annelid commensal, with a sponge." It was about four inches high, and came from a Cretaceous horizon. In general aspect it bears a resemblance to the "screw stones" of Heer and to the gigantic fossils of Nebraska, *Daimonelix*. While it would be rash to conclude that all these are of the same nature, it is at the same time interesting to note something of a resemblance.

Joseph F. James, M. D.

Hingham, Mass., June 13, 1896.

PERSONAL AND SCIENTIFIC NEWS.

Prof. G. D. Harris, of Cornell University, is spending the summer in Alabama, making paleontological collections fo the University. (*Science.*)

*Vol. xv, pp. 337-342, pl. 2.

PROF. J. PAUL GOODE, of the State Normal School at Moorehead, Minn., delivered two courses of lectures on physiography at the summer school of the University of Minnesota.

WILLIAM WILLIAMS MATHER. A sketch, with portrait, of this geologist is given in *Appletons' Popular Science Monthly* for August. Mr. Mather is known especially for his fine work on the Geological Survey of New York during its early years, and also as the first state geologist of Ohio.

PROF. G. FREDERICK WRIGHT, in the preface of the new fourth edition of "The Ice Age in North America," dated last June, gives in seventeen pages an enumeration of the principal contributions to the literature of the glacial geology of this continent during the past five years, with occasional notes of comment and criticism.

THE CALIFORNIA STATE MINING BUREAU has recently issued (Bulletin No. 8, April, 1896) a statistical table showing by counties the mineral productions of the state for the year 1895. The total product amounted to $22,844,664.29, or an increase of more than two and a half millions over 1894. The production of precious metals for 1895 was $15,934,107.39, of which almost $600,000 was silver and the balance gold. The table was compiled by Charles G. Yale, statistician, from direct returns from the producers.

THE FOUR-TUSKED MASTODON. On page 325 of this magazine for May, 1895, in a notice of the Mastodons recently set up at Cincinnati, the remark is made that the Mastodon with two tusks in the lower jaw has been hitherto limited to the Old World. Referring to this passage, professor B. K. Emerson writes. "The museum of Amherst College contains a specimen of *M. americanus* with both the tusks preserved in the lower jaw. They are ten inches long and two in diameter." The same museum also contains the two lower tusks of *M. shepardi* from California, described by Dr. Leidy.

PROF. J. D. WHITNEY, of Cambridge, Mass., died at New London, N. H., Aug. 19, at 77 years of age. Prof. Whitney was graduated from Yale in 1839, and in 1840 he made an extended survey of New Hampshire. In 1847 he made a geological exploration of the lake Superior region, followed by a survey of the mining regions of all the states east of the Mississippi river. In 1855 he was appointed state chemist of Iowa and professor of the Iowa State University. In 1860 he was appointed state geologist of California and five years later he was made professor of geology of Harvard university. In 1870 Yale honored him with the degree of LL.D. In a future issue the GEOLOGIST will contain a suitable sketch of this eminent geologist.

NANSEN'S POLAR EXPEDITION.

Tidings were received August 13th from Vardoe island, Norway, by the steamer Windward, on her return from carrying supplies to the Jackson-Harmsworth expedition, announcing the arrival of Dr. Fridtjof Nansen in Franz Josef land. As reported by telegrams, he states that his steamer, the Fram, was frozen in the ice-pack near the end of September, 1893, in latitude 78° 7' N. and longitude 133° 37' E., near the northwestern shores of the New Siberia islands. During the winter and spring they drifted to the north and northwest, reaching 81° 52' N. on June 18, 1894, after which, during the summer, the course of the drift was southerly. Changing in the autumn again to northward drifting, they reached the latitude of 83° 24', the farthest ever previously attained (by Lockwood and Brainard), about Jan. 1, 1895. On Jan. 4 and 5, while the Fram was frozen in floe ice thirty feet thick, this floe was overriden by ice masses which threatened to crush the steamer. After escaping safely, however, from this peril, the drift continued toward the northwest.

Leaving the steamer and crew at 84° N. and 102° E., about midway between cape Chelyuskin and the pole, Nansen, with one companion, Lieut. Hansen, advanced afoot with sledges to latitude 86° 14', lacking only 226 geographical miles to reach the pole. Thence turning back, they came to the north coast of Franz Josef land, and built a stone house in which they spent the winter of 1895-96. On June 17th of the present year, while Nansen and his comrade were setting out for a journey across the floe ice to Spitzbergen, they were met by Dr. Jackson, of the Jackson-Harmsworth expedition, who had wintered in a more southern part of Franz Josef land. Nansen believes that the Fram, in charge of Capt. Sverdrup and the others of the crew, whom he left in good health, will successfully endure the long ice drift, and that even this year, having been carried into open water, the Fram may safely return to Norway.

The drift carried the Fram more westward and less poleward than was hoped, and its release from the floe ice will be apparently between Franz Josef land and Spitzbergen. After passing latitude 79°, northwest of the New Siberia islands, the sea, to that latitude no more than 90 fathoms deep, was found to increase rapidly in depth to soundings of 1,600 to 1,900 fathoms.

POSTSCRIPT. On August 20th, just a week after the first news from Nansen, and after the foregoing had been written, the prophetic expectation of the intrepid explorer for the return of his ship and crew was verified by a telegram from Capt. Sverdrup, that the Fram, with all on board well, has reached the northern islands of Norway, on her way to the port of Tromsoe. W. U.

Prof. H. B. Patton, in a paper read before the Colorado Scientific Society Nov. 4, 1895, describes and illustrates bedded volcanic conglomerates and breccias in the upper Rio Grande valley. The depth of these volcanic formations he estimates at thousands of feet. The rock is usually basic or andesitic, consists of pebbles, boulders, etc., imbedded in a tenacious, fine ash. Under rain and erosion the rock takes on fantastic shapes and stands in isolated columns and peaks.

The Polar Cap of Mars. Mr. Percival Lowell has a discussion of recent observations on the ice-cap of Mars in "Popular Astronomy" for September, accompanied by a chart showing its shape and various sizes from June 3 to Oct. 5, 1894, and the intersecting canals. The center of the cap is about 6° excentric from the geographic pole of the planet, and its most northern extension (the cap is on the south pole) is to about latitude 55°. The much discussed canals are explained as natural rifts in the cap along which the body of the planet is uncovered, or in which the oceanic waters enter. The entire cap is formed and melted annually.

Facts about the Great Lakes. Mr. P. Vedel has tabulated the physical features of the great lakes in a late number of the Journal of the Western Society of Engineers as shown below.

	Length miles.	Average width, miles.	Maximum width, miles.	Shore line, miles.	Water area (including islands), square miles.	Average depth, feet.	Maximum depth sounded, feet.	Surface above tide-water, feet.	Deepest point above tide-water, feet.	Water volume, cub. miles.	Land area of water-shed, square miles.	Aggregate water and land area of water-shed, sq. miles.
Lake Superior......	390	70	160	1300	31200	475	1008	602	−408	2800	51600	82800
St. Mary's river.....	53 / 40	2½ / 2	5 / 4	100	200	....	53	...	......	....	800	1000
Lake Michigan.....	335	58	85	875	20200	335	870	581	−289	1290		
Green Bay...........	115	15	21	280	1700	95	144	581	+437	30	37700	60100
Mackinac straits....	30	16	23	60	500	75	234	581	+347	7		
North channel......	110	12	18	220	1400	70	240	581	+341	20		
Lake Huron........	250	54	100	725	17400	210	702	581	−121	650	31700	55700
Georgian bay.......	120	40	58	390	5200	170	462	581	+119	170		
St. Clair river.......	35	1	...	70	30	....	....	....	......	....	3800	3830
Lake St. Clair......	19	25	29	90	410	....	21	575	+554	1	3400	3810
Detroit river........	27	2	3¼	54	60	....	....	....	......	....	1200	1260
Lake Erie...........	25	40	58	590	10000	70	204	573	+369	130	22700	32700
Niagara river.......	34	1	2	70	60	....	....	....	......	....	300	360
Lake Ontario.......	180	40	58	600	7300	300	738	247	−491	4.0	21600	29.0
St. Lawrence river..	760	20	95	....	......	....	....	....	......	....	....	....
Totals...........	...	...	....	5404	95660	....	....	....	......	5508	174800	270460

The International Congress of Geologists.

The general committee of organization has issued through Messrs. A. Karpinsky, president, and Th. Tschernyschew, secretary, a circular of information concerning the seventh session of the International Congress of Geologists. The session will be held at St. Petersburg in the latter part of the month

of August, 1897, and will last about eight days. The meetings will not be held by sections as at Zurich. They will be devoted to the discussion of general principles which in the present state of geological science are likely to lead to satisfactory results. And in Russia, specially, it is hoped, by the committee, that communications be made on important geological work that has been undertaken, the results of which cannot yet be published, and on new methods of scientific study not yet published. There will be special meetings with the different scientific societies during the session of the Congress, at which both Russian and foreign geologists may present communications on any new discoveries, new instruments, etc. Halls will be put at the disposition of members of the Congress for the exhibition of geological maps, profiles, specimens, etc.

The excursions that will be made in connection with this session of the Congress will be a memorable feature. As was announced at the Zurich session, they will be of two sorts:

1. Those designed to afford examination of certain interesting localities.

2. Extended general excursions.

The first of the extended excursions will be special with respect to the Ural and general with respect to the regions that will be traversed in order to reach that chain, and will take place before the opening of the Congress, i. e., from the 29th of July to the 22d of August. It will be under the direction of Karpinsky, Nikitin, Tschernyschew, Krasnopolsky and Stuckenberg. It will start from Moscow and will touch the following points: Riazan, Penza, Syzran, Samara, Oufa, Zlatooust, Tcheliabinsk, Kychtym, Ekaterinebourg, Taguil, Kouchva, Perm, Kazan, Nijni-Novgorod, Moscow, St. Petersburg.

For those geologists who are interested in the region of the Volga there will be a variation in this excursion. The participants will visit, under the direction of S. Nikitin, the banks of the Volga, from Samara to Kazan, where they will rejoin the excursion returning from the Ural.

At the same time as the excursion to the Ural another will go into Esthonia, under the guidance of Fr. Schmidt, where the participants will note the Cambrian, the Silurian and the glacial formations. This excursion will occupy about twelve days.

It is also proposed to organize an excursion into Finland before the opening of the Congress. This will be under the direction of Messrs. Sederholm and Ramsay and will be planned for the examination principally of the crystalline rocks and the glacial formations.

After the close of the Congress there will be a long excursion as follows:

1. From St. Petersburg, visit Moscow and its environs.

Division into three sections.

Section A.

2. From Moscow to the basin of the Donetz: study of the Carboniferous sediments in the region of Moscow, Kharhow, etc.

Valley of the Donetz (under the direction of Tschernyschew and Loutougin).

Voyage to Vladikavkaz and visit to the mineral waters.

Section B.

2. From Moscow to Nijni-Novgorod; voyage by steamer on the Volga and to Vladikavkaz (under the direction of Pavlow and Amalitzky).

Section C.

2. From Moscow to Kiew, by the Dnieper to Vladikavkaz (under the direction of Sokolow and Thiophilaklow).

The three sections continue after reunion at Vladikavkaz.

3. From Vladikavkaz to Tiflis, by the military road of Georgia; visit to the glaciers (under the direction of Loewinson-Lessing).

4. Tiflis and Bakou (guidance of Simonowitsch, Konschin and Sjögren).

5. Tiflis—Batoum. Visit to Tkviboul (under the guidance of Simonowitsch).

6. From Batoum to Kertch.

7. Kertch and other parts of the Crimea (guidance of Androussow, Lagorio, Golovkinsky, Vogt and Karakasch).

10. Sebastopol.—Final meeting and close of the Congress.

The whole excursion, from St. Petersburg to Sebastopol, will require about a month.

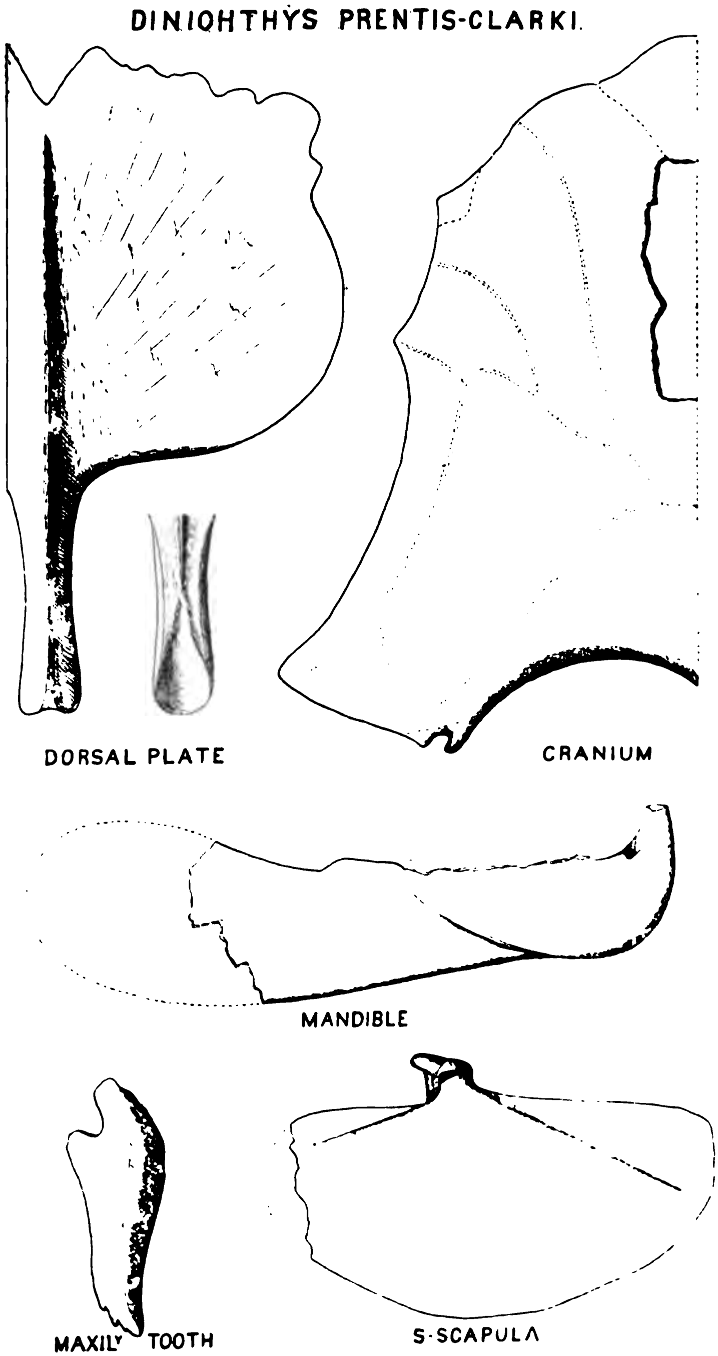
From this general excursion there are to be six different variations for special points of interest in central and southern Russia, under guidance of some Russian geologists, the participants uniting again with the main excursion.

An excursion will be organized to visit specially the Caucasus direct, without stopping in central or southern Russia if a sufficient number of geologists express such a desire. This will take about twenty days.

The committee desires to be informed, before the month of October, which excursion geologists will take part in. The expense attendant on these excursions will be carefully estimated and notice of each will be given later.

His majesty, the emperor, has granted to all geologists who give, in sufficient time, their notification of attendance on the Congress, tickets giving free travel on the Russian railroads during their stay in Russia, before and after the Congress, including the excursions.

N. H. W.



DINICHTHYS PRENTIS-CLARKI.

THE

AMERICAN GEOLOGIST.

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[PALÆONTOLOGICAL NOTES FROM BUCHTEL COLLEGE, No. 13.]

DINICHTHYS PRENTIS-CLARKI.

E. W. CLAYPOLE, Akron, O.

(Plate VII.)

During the season of 1895 Dr. Clark found a specimen which he considered a new species of Dinichthys. He showed it to me, and upon close examination there remained little doubt that his opinion was well founded. Its leading characters are accordingly given in the present note. Fortunately a considerable portion of the cranial armour was found, so that more details can be given of this than are known of some of the species hitherto described.

From almost all the known forms it is readily distinguished by obvious differences. Two only resemble it so closely as to render confusion possible. These are *D. gouldi* and *D. intermedius*. Of the former the mandible is only imperfectly known. But this shows a long cutting blade and merely a rudiment of the second cusp, whereas in the fossil now in hand the latter, though lost, was obviously present in life as shown by its remaining base, and the cutting edge of the mandible was apparently short. But in regard to the latter character, the broken condition of its upper edge makes a positive statement on this point impossible. The opinion expressed above is, however, supported by the beveled margin of the maxillary hereafter to be mentioned.

From *D. intermedius* its separation is not difficult on the ground of size alone. The mandible, when complete, did not exceed six or six and a half inches in length, or less than half of that of the larger species. It is also much less massive. but in general outline the two are not unlike. The cranium also occurs entire, as in that species, and is figured in our diagram. It shows all the plates outlined in the engraving of *D. intermedius*, given in the AMERICAN GEOLOGIST for October, 1892 (Vol. x). The two sockets on the ex-occipital plates for receiving the tenons of the supra-scapulas are, as usual, broken, it being impossible to separate these plates so long as both are entire. The pre-orbital plates, though imperfect, indicate less prominence than in the cranium of *D. intermedius*. The brain cavity is crushed in, the bone covering it being thinner than the adjoining plates. The ethmoid is detached and only one-half of it was found. The two premaxillæ remain nearly in place, but so forced into the plate above them that they form prominences on the upper surface. They differ somewhat in form, perhaps in consequence of use, but it is worth notice that the grooves worn in the outer edge of the mandibles by friction differ in the same manner. The sensory canals are distinct, and their course may be more readily traced over the skull than in any other specimen yet figured. They are indicated by double dotted lines.

Fragments of both suborbitals were secured, but they are too imperfect for figuring and present no peculiar characters.

The maxillary tooth of the left (?) side is figured and shows three denticles near the point. It is almost certainly beveled by friction against the mandible.

The medio-dorsal plate is small, measuring but seven and a half inches in extreme length (of which the narrow projecting stem takes up two and a half inches) by six inches in greatest width. It is almost perfect, as shown in the figure, but presents no characteristic feature calling for notice.

The supra-scapula or ante-dorso-lateral plate is remarkably elongate laterally and very short in the fore and aft direction. The well marked tenon is strengthened by a flange connecting its whole length with the main plate, which shows extensive underlapping surfaces on its exterior aspect. Fragments of

other plates have also been recovered, but they afford at present no additional knowledge regarding this or other species.

I have much pleasure in naming this species after the son of its discoverer, whose enthusiasm in the work promises greater results in the future, *Dinichthys prentis-clarki.*

THE FORT UNION FORMATION.

By WALTER HARVEY WEED, Washington, D. C.

The Fort Union group is a name familiar to all students of the Cretaceous formations of the Northwest. First used by Dr. F. V. Hayden, whose explorations of the upper Missouri form the basis of our present knowledge and classification of the Cretaceous of the great plains country, the name designated the great lignite group of the "Country around Fort Union, extending northward into the British possessions to unknown distances; also southward to Fort Clark."* At the time the name was given the formation was also identified on the North Platte river above Fort Laramie, and on the west side of the Wind River mountains. Afterwards it was extended so as to include all the beds referred later to the Laramie (excepting the Judith River beds), as well as some still older formations. Abandoned by its sponsor for the later term Laramie, the name retained its place in geological literature owing to the earnest efforts of Dr. J. S. Newberry, who maintained that the beds to which the name was first applied constitute a totally distinct and independent formation of later age than the Laramie.† In his last paper upon this subject professor Newberry expressed his views quite clearly and forcibly, paying tribute to professor Ward's scholarly paper upon the flora of the Laramie group, which he claimed was really a description of the flora of the Fort Union formation. A later paper by Knowlton‡ accepts this view.

It seems unnecessary and out of place in this paper to discuss the relations of the Laramie group, except to show that the Fort Union group does not belong to it. The recent dis-

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*Proc. Acad. Nat. Sci. Phila., vol. XIII, 1861, p. 433.

†The Laramie Group. Trans. N. Y. Academy of Sciences, vol. IX, No. 1., Nov. 4, 1889. Also Bull. G. S. A., vol. I, p. 524.

‡Fossil Plants from the Fort Union group of Montana. Proc. U. S. National Museum, vol. XVI, p. 33, Washington, 1893.

coveries in Colorado and the critical reviews of White* and Ward† have practically settled the question for all time.

Time has shown that this conclusion of Dr. Newberry is correct, and as the name seems the only fitting and proper term by which to designate a formation of wide geographical extent in the region of the great plains of the Northwest, occurring from Dakota westward to the Rocky mountains, it is fitting that the name should be defined, its meaning clearly given, and the reasons for its use concisely stated.

The object of the present paper is to show that there is in Montana a group of strata, including those originally called Fort Union, which overlie and are of latter age than the post-Laramie (Livingston) beds; that these beds are of fresh-water origin, characterized by a distinct flora of Eocene types; and that the series is entitled to recognition as a distinct formation upon lithological, stratigraphical, and paleontological grounds.

Introductory.—The sedimentary beds exposed in the bluffs of the Missouri river at the confluence of the Yellowstone, where the former military post of Fort Union was situated, were the first lignite-bearing beds of the great plains region thoroughly explored by Meek and Hayden. Extensive collections of the fossil plant remains from these beds were made by Dr. Hayden, which were placed in the hands of Prof. J. S. Newberry for study. A large portion, possibly all of the plants described by Newberry in his *Later Extinct Floras*,‡ came from the valley of the Yellowstone. This valley was explored by the party to which Hayden was attached, for a distance of 100 miles or more above the mouth of the river. The plants were brought down to Fort Clark and were labeled Fort Union. The Eocene age of this fossil flora was recognized by Newberry, but the failure of Dr. Hayden to discriminate the formation from the Laramie caused much discredit to fall upon fossil plants as criteria of the age of strata, and proved one of the chief hindrances to a true understanding of the age and relations of the Laramie group.

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*Synopsis of the Flora of the Laramie group. 6th Ann. Rep. of the Director of the U. S. Geological Survey.

†Bull. 82, U. S. Geological Survey. Cretaceous.

‡N. Y. Lyc. Nat. Hist., IX, 1869, p. 27.

The name Fort Union, applied to the Fort Union beds, was afterwards extended by Hayden to include all the lignite-bearing beds of the Northwest, for which the term Lignitic group* was afterwards used.

By agreement with Mr. Clarence King, the term Laramie,† used for the prominent coal-bearing horizon of the region of the 40th parallel, was accepted by Hayden, who extended it to include all of his Lignitic group, and he included in this all the lignitic strata of Montana. Explorations in the upper Missouri region by C. A. White and L. F. Ward in 1881-3, T. W. Stanton in 1894, and at various times from 1884 to 1895 by the writer, have shown that the lignite or coal seams of this region are of very different age, the oldest being Lower Cretaceous (Kootanie). A higher horizon, Belly River beds, occurs in the middle part of the Upper Cretaceous series, and other commercially available coal beds are found in the Fox Hills, in what is now discriminated as true Laramie, and in the upper series which the author has for some years tentatively designated as Fort Union beds. It is therefore evident that the Lignitic group of Hayden comprises strata of very different age and relations, and that the application of the term Laramie as its equivalent has misled some investigators into a fundamental error that has vitiated conclusions reached in the discussion of the relationships of the Laramie, based wholly or in part upon the facts gathered in the upper Missouri region.

Livingston formation.—In pursuance of the geological work of the U. S. Geological Survey in Montana, in has been the duty of the writer to map the areal geology of some 10,000 square miles along the eastern border of the Rocky mountains, and to make a reconnaissance of other parts of the state. In the course of this work it soon became apparent that the use of the term Laramie group would have to be restricted to designate the series of brackish and fresh-water beds, usually coal-bearing, which terminated the Cretaceous. This distinction, which accords with the original definition and usage of the word, was necessary because it was found that, while perfect conformity apparently existed throughout the strati-

*Proc. Acad. Nat. Sci. Phila., vol. xviii, p. 433, Dec. 1861.
†U. S. Geol. Explor. 40th Parallel, vol. i, p. 331.

graphic series exposed in eastern Montana, from the Dakota upward, yet along the Rocky mountain front the coal-bearing Laramie beds are succeeded by a great series of beds that are of peculiar lithological character and possess a distinct flora nearly identical with that of the post-Laramie Denver beds of Colorado, and show in several places marked unconformity with the Laramie, both stratigraphically and in the composition of the conglomerates found in the series. This series of beds the writer designated as the Livingston formation,* and the conclusions as to its age and relation to the Laramie have been confirmed by conclusive evidence gathered by Dr. A. C. Peale, in the vicinity of the Gallatin valley.†

To clearly understand the importance of the Livingston and of its occurrence between the Laramie and Fort Union formations, the evidence may be summarized as follows: The Livingston formation is post-Laramie. It is formed chiefly of assorted and water-worn volcanic material, rests unconformably upon Laramie and all the earlier Cretaceous terranes of the region, and includes conglomerates, recording a prolonged period of post-Laramie uplift and erosion; it is charterized by a flora of post-Laramie type and by a purely fresh-water fauna.

Fort Union Formation. The plant and invertebrate remains characteristic of the strata at the type locality constitute a peculiar flora and fauna. The characteristic species of this locality have been recognized in the beds overlying the Livingston formation near the Crazy mountains; and as this is the only region known where the Cretaceous, including the Laramie formation, is succeeded by both the Livingston and Fort Union formations, its occurrence here will be described somewhat fully.

In the region north of the Yellowstone river, less than 100 miles north of the National Park, the imposing group of peaks known as the Crazy mountains is the most conspicuous feature of the landscape. These mountains are formed of Livingston beds, conformably overlain by a series of sandstones and clay-shales, characterized by fresh-water fauna, and lithologi-

*Bull. 105, U. S. G. S.
†Three Forks, Montana, Geological folio of the U. S. Geological Survey.

cally distinct and readily differentiated from the somber colored sandstones of volcanic material composing the Livingston beds. The plant remains from these beds are not of Laramie nor of Denver bed types, but are species characteristic of the strata in the vicinity of Fort Union, and that name is therefore adopted for the formation. As will be shown later, the formation is one of widespread extent in the plains country of Montana, and it extends northward into Canadian territory.

The Fort Union formation as developed in the Crazy mountains consists of a series of alternating sandstones and gray clay-shales, the latter holding limestone concretions often many feet in diameter at various horizons. The sandstones are usually light gray in color, loose-textured, and frequently crumbly, cross-bedded, and often hold round cannon-ball concretions which are merely indurated sandstones. The grains are generally water-worn and rounded fragments of quartz, more rarely of feldspar, and are of gneissic origin. The character of the quartz and the abundance and nature of the feldspar fragments differ markedly from those normal to the underlying Livingston beds. The clay-shales are sometimes calcareous, generally gray in color, weathering into fine, cubical debris. The limestones are dense and flint-like, breaking with conchoidal or splintery fracture. They are gray but weather with light earthy brown surface, and are sometimes fossiliferous. Lignites occur rarely, are impure, friable, and of little economic value, differing every way from the coals of the Laramie.

A continuous section measured at the base of the mountains, embracing marine Cretaceous (Montana group), Laramie, Livingston, and Fort Union beds, is given below:

Section of Strata forming Eastern Footslopes of the Crazy Mountains, on Lebo Creek, Montana.

Feet.

885 Sandstones; light colored, generally brownish or buff, of varying coarseness, texture, and hardness; in thick and thin beds, sometimes cross-bedded and often fissile.

755 Alternating series of sandstones and shale: the latter gray, argillaceous, not laminated, weathering in smooth slopes with fine cubical debris and frequently holding large and small limestone balls and ovoids. These consist of dense and hard, flinty gray limestone, generally checked and cracked,

	often with calcite seams, and the masses weather with an umber brown surface.
1	Limestone; carrying shell remains.
700	Series of alternating light colored sandstones and gray shale, like that above.
5	Shales; carrying fresh-water fossils.
714	Series of alternating sandstones and shales, similar to those noted above.
5	Lignite seam; several other impure seams occur in 100 feet of beds above.
27	Shales and sandstones.
4	Sandstone; containing fresh-water fossils.
10	Gray shales.
2	Lignite seam.
635	Series of beds of sandstones alternating with gray argillaceous shales of varying nature.
5	Limestone; containing fossils.
900	Sandstones of varying texture, carrying occasional beds of limestone.
7136	Livingston formation; dark colored conglomerates, grits, sandstones and tuffs, with interbedded tufaceous shales, all composed largely of volcanic debris.
1080	Laramie formation; sandstones, buff and gray, with interbedded shale.
500	Fort Pierre shales, and Fox Hills sandstone.

The importance of this section, which is the only one known to the writer in which the Fox Hills, Laramie, Livingston and Fort Union formations occur superimposed, is apparent when it is considered that in eastern Montana and Canada the Fort Union rests directly upon Laramie beds in apparently perfect conformity.

The invertebrate remains from the beds noted in the section just given are all fresh-water forms. They have been determined for me by T. W. Stanton, who reports the following species:

Viviparus trochiformis M. & H.	Valvata subumbilicata M. & H.
V. retusus ?	Goniobasis tenuicarinata M. & H.
V. leai ?	Unio priscus ? M. & H.
Bulinus longiusculus ? M. & H.	U. couesii.
B. subelongata M. & H.	U. danæ ? M. & H.
Campeloma multilineata M. & H.	U. primævus.

Of this fauna, Mr. Stanton says:*

*Mss. Official Report to Director of U. S.G.S., upon request of writer.

"Almost all the species in the list were originally obtained near Fort Union on the Missouri river. *Viviparus trochiformis* came from 10 miles below Fort Union. It has also been found at the base of the Wasatch Eocene at several localities in central Utah. *Goniobasis tenuicarinata* has the same distribution and also occurs in the Laramie on Crow creek, northern Colorado. The types of *Campeloma multilineata* came from Fort Union beds at Fort Clark, Dakota. It has been found on Heart river, Dakota, and in the Laramie of Crow creek, Colorado. The original locality of *Unio primævus* is south of Cow island, upper Missouri river, Montana. *Unio danæ* was described from the Judith River beds at the mouth of the Judith river. Two of the species pass up into the Tertiary."

Vertebrate remains have not been found in the Fort Union beds of the Crazy mountains, only a single rolled and water-worn fragment having been seen. This fragment of bone was turned over to Mr. F. A. Lucas and by him shown to Prof. E. D. Cope. Mr. Lucas reports as follows: "Professor Cope says the sandstone is Laramie and the bone is part of the humerus of a dinosaur."

The plant remains of these beds are abundant in certain localities, though but small collections have been made from three places, viz., (1) north slopes of Fairview peak, the most southern summit of the mountains; (2) from the foothills on Sweet Grass creek; (3) from the foot slopes near Big Timber creek. These collections have been examined by Prof. F. H. Knowlton, who reports that the species are in general of Fort Union types, that is, belong to, or most closely resemble, the flora of the beds at the mouth of the Yellowstone.

Of the specimens from Big Timber creek he says: * "A small collection of fossil plants obtained at the foot of the Crazy mountains on Big Timber creek, Park county, Montana. The collection numbers nine specimens which I have been able to identify as follows: A single specimen each of *Sequoia langsdorfii* Heer and *Populus genatrix* Newberry, and four specimens of *Ulmus speciosa?* Newberry, with fragments of a *Platanus* (possibly *P. nobilis*), a *Phragmites*, and *Ulmus* sp.

*Bull. 105, U. S. G. S., p. 63.

"*Sequoia langsdorfii* has been abundantly found in, but is not confined to, the Fort Union group, while *Populus genatrix* and *Ulmus speciosa* are typical Fort Union plants. While it is manifestly unsafe to place much dependence in such meager data all the species identifiable belong to or are found in the Fort Union group."

"I have examined the plants from Sweet Grass creek, and am unable to identify a single species with entire satisfaction as belonging to the Fort Union flora. Four or five species appear to be represented as follows: Numerous specimens of a conifer that is probably *Sequoia langsdorfii*, but the branchlets are smaller than is usual, with spines, and the leaves are much shorter. There are about a dozen specimens of a fern that was at first supposed to be *Onoclea sensibilis fossilis*, but more careful study seems to prove that it cannot be this. It is undoubtedly quite close to this species, but differs in details of vernation. It will have to be described as a new species. Associated with this fern are two examples of what may be the fertile branches; but in absence of proof connecting them, it will probably be best to describe them as new also.

"There is also a very fine dicotyledonous leaf that must have been seven or eight inches in length and between four and five inches in width. It is broadly ovate in outline, with a broad heart-shaped base, and has five palmately arranged verns, all springing from the petiole. I am uncertain as to its affinities. A number of other dicotyledons are too fragmentary to admit of even generic determinations.

"In a general way these resemble Fort Union plants, but none of them belong without question to this flora."

The strata to which the name of Fort Union was first given form the bluffs of the Missouri river in the vicinity of the mouth of the Yellowstone. The beds include two horizons, lithologically distinct. The locality was visited by the writer in company with Prof. C. D. Walcott in August, 1895. The bluffs north of the Missouri river near Willow station were carefully noted. The lower part consists of light colored gray sands with rusty lenses and concretions, forming caps that cause picturesque pillars and exposures. There are probably 50 to 75 feet of this sandy series exposed, which is capped by the clay series and lignites.

Seen from below, the exposure shows three prominent seams of lignite, whose dark lines are everywhere noticeable in the adjacent bluff exposures. Examined in detail, the series includes at least five other seams which are from 1 to 2 feet in thickness, but which are covered in the exposure by the wash of the silty, intervening beds. The section was made about a mile west of Willow station.

Section of the north bluff of the Missouri river, near the mouth of the Yellowstone.

Feet:	
5	Sandy, buff colored beds alternating with gray beds, 3 to 5 feet in thickness. The general appearance of the upper part of the bluff is that of a smooth, clay slope, as the silty wash from above partially obscures the outcrops of the strata.
7	Gray and ash-colored clays carrying fresh-water shells, the outcrop showing a cracked and muddy surface.
1	Lignite (?) seam.
3	Limestone; yellowish in color and breaking into small, angular bits, the largest ¾" in diameter. The horizon is inconstant, the limestone really forming a lens.
4	Arenaceous clays, buff in color and forming the summit of a prominent bench that circles the bluff.
1½	Gray shale, carrying shell remains.
2	Lignite seam, impure and weathering to a fine Carboniferous clay.
4	Gray shale.
5	Lignite seam, overlain by flaky, laminated shale, carrying shell remains.
15	Argillaceous, ashy gray shales, weathering into a silty wash.
6	Light colored bed, whose outcrop is covered with an alkaline efflorescence and with the brittle, shreddy fragments of limestone from the weathering of a concretion of this material, whose surface is of a rich terra cotta color. The base of this zone forms a platform terrace that is 6 feet wide.
15	Sandy beds, soft, reddish buff in color, resembling a silt in appearance and weathering with a pitted surface.
25	Loosely cemented sands with concretions, illustrated in the photographs (C. D. W., 1895). These concretions have all shapes and sizes, up to 6 feet in diameter. The bed forms a marked sandy layer, but is not hard enough to weather as a ledge.

The fossil plants collected from the Williston locality show only one species, *Onoclea sensibilis* Linn., *fossilis* Newb. The shells obtained from the section just given are of fresh-water species and are of forms common to the Laramie and Fort Union beds. They have been identified by Mr. Stanton as *Viviparus trochiformis* M. & H., *V. leai* M. & H., and fragments of *Unio sp.*

The collections of fossil plant remains in the possession of the National Museum from the neighborhood of the original Fort Union locality are very full. They have been studied by professor Knowlton, who reports that the Fort Union flora embraces 169 species. Of this number 130 species are confined to this formation. Of the 39 species found in other terranes, 21 occur in the Miocene, 14 in the Denver (post-Laramie), and 9 in the Laramie. These figures tell their own story. Professor Knowlton states that the flora as a whole is clearly Eocene. This confirms the statements of Newberry,* that the floras of the Laramie and the Fort Union are totally distinct, and that these formations should be referred to different geological horizons, the Fort Union to the Tertiary, and the Laramie to the Cretaceous.

The clearest description of the Fort Union formation, as developed in the Great Plains region north of the International boundary, is given by Tyrrell,† in which the series is described under the name of the Paskapoo beds and grouped with the underlying series under the term Laramie. He states that what he calls Laramie consists of two formations, distinct lithologically and paleontologically. The lower, or Laramie proper, he calls the Edmonton series. It rests in perfect conformity upon the shales of the Pierre (Montana) group, and is covered westward by a higher series which he calls the Paskapoo series. The latter corresponds in every detail to our Fort Union. It is of purely fresh-water origin and is quite distinct, lithologically, from the white sands and white sandy clays of the Laramie. Contrasted, the Edmonton contains abundant vertebrate remains, mainly dinosaurs; the Fort Union (Paskapoo), none. The flora of one is Laramie; the species of the other are not Laramie types, but are identical with those from the Fort Union of Montana. The fossil flora of these Fort Union beds of Canada has been studied by Sir J. William Dawson, who identified 29 species, all of which, according to professor Knowlton, belong to the Fort Union Eocene flora.

*See Ward, Syn. of Flora of Laramie Group. Newberry. Bull. G. S. A., vol. 1, p. 524.

†Ann. Rep. Can. Geol. Survey, 1886, p. 136 E.

The following table shows the comparative sections found along the Rocky Mountain front:

AGE.	MONTANA.	CANADA.	COLORADO.
Eocene.	Fort Union.	Paskapoo. 5,700' { Porcupine hills. Willow creek.	
Post-Laramie.	Livingston.	(Erosion interval.)	{ b. Denver beds. a. Arapahoe beds.
	Unconformity.		Unconformity.
Cretaceous.	Laramie.	Edmonton (Tyrrell). (Wapiti river, Dawson.)	Laramie.

VOLCANIC ASH FROM THE NORTH SHORE OF LAKE SUPERIOR.*

By N. H. Winchell and U. S. Grant.

It is a peculiar feature of that vast series of surface igneous rocks, belonging to the copper-bearing series on each side of the western half of lake Superior, that deposits of volcanic ash are not common. In fact, Irving stated that he considered such materials as entirely lacking.† Selwyn saw rocks on Michipicoten island which he referred to as tuffs‡ and this seems to be the only direct reference, made in late years, of rocks of this age to volcanic tuffs. In the examination of a series of rocks belonging to the Geological and Natural History Survey of Minnesota, from the north shore of lake Superior, several have been found which possess the characteristics of fragmental volcanic deposits. The best examples of these are Nos. 8A, 17, 24 and 61 of the Minnesota Survey collection,§ but there are also others which are of the same nature but do not show their origin so clearly. The rocks here mentioned are from Duluth, or the immediate vicinity, and belong in the series which is usually termed Keweenawan. Some of them are probably from the gray sandstone at Duluth which Irving said it was barely possible contained volcanic ash material.‖

In general these rocks macroscopically resemble fine grained, impure sandstones, and they vary in color from reddish brown

*Presented before Section E of the American Association for the Advancement of Science, August 25, 1896.

†R. D. Irving: U. S. Geol. Survey, Mon. 5, p. 32, 1883.

‡A. R. C. Selwyn, Science, vol. 1, pp. 11, 221, 1883.

§For description of the field relations and localities of these rock samples see Geol. and Nat. Hist. Survey of Minn., 9th Ann. Rept., pp. 12, 14, 20, 1881.

‖R. D. Irving: *Op. cit.*, p. 138.

to ashen gray. They separate rather easily into parallel layers which have the usual dip of the surrounding rocks, into the lake(i. e., south southeast) at a low angle, although occasionally this angle increases to 40 degrees or even more and there are also local deviations in the direction of the dip. In the vicinity toward the west occur gabbro and red granites, while the surface rocks with which these tufaceous rocks are immediately associated are diabases, diabase porphyrytes and basalts which are frequently amygdaloidal, and aporhyolytes; and they are sometimes cut by diabase dikes. As a rule, these tuffs are quite fine grained, the different particles being usually less than an eighth of an inch in diameter. and their origin is not clear except when studied in sections. Accordingly the salient features of some of these sections are here given.

No. 17 is composed of small fragments surrounded by a matrix of very fine grain consisting of quartz, feldspar, chlorite, epidote, calcite and iron ore. all of which are secondary grains and not original fragments. The fragments, which are the peculiar feature of the section, are of all shapes, from roughly rounded and oblong forms to those which are jagged and very irregular in outline. They are usually surrounded by a rim of minute iron ore granules which render the outline of the fragments very distinct. Many of the fragments are vesicular, having one or more rounded vesicles whose sides are also surrounded by granules of iron ore. The interior of the fragments is a confused mass of small grains and flakes, which are principally chlorite, with epidote, quartz and iron ore. It seems impossible to reach any conclusion other than that these fragments are pieces of vesicular volcanic material, probably originally glassy but now devitrified.

No. 61 is composed mostly of small, closely crowded grains which are largely rounded or subangular. These grains are chiefly of three kinds: (1) greenish grains, (2) feldspar, and (3) quartz, the last not being as common as the other two. The greenish grains are usually composed of minute flakes of chlorite and a micaceous mineral, probably sericite. with some quartz. Other grains are composed of an aggregate of minute grains of quartz and feldspar, the former

sometimes embracing the latter poikilitically, much resembling the devitrified groundmass of ancient acid lavas from this locality. The feldspar grains are altered and much filled with calcite and sericite, and these two minerals, together with secondary quartz and chlorite, are in the interstices between the grains. But the most striking feature of the rock is the presence of a number of larger roughly angular grains which are similar to some of the smaller rounded ones and which appear to be composed of the products of devitrification; and what is still more confirmatory of this idea is that some of these grains still show very clearly the remains of a perlitic parting common to glassy rocks. This perlitic parting has been found in great perfection in some of the devitrified acid lavas of the north shore of lake Superior and is similar to that described from the aporhyolytes of South Mountain in Maryland and Virginia.*

The two rock samples just mentioned are perhaps the most characteristic of a number of similar rocks from the north shore of lake Superior but mostly from the vicinity of Duluth. There seems to be no other interpretation of their characters possible than to refer these rocks to volcanic ash deposits. While remains of fragmental volcanic material are not known to be abundant, still such deposits do occur in rocks which are usually considered as Keweenawan in age. No craters have been located, but it seems quite probable that future careful investigations may enable us to locate exactly some of the vents where explosive volcanic action occurred.

BUFFALO MEETINGS OF THE GEOLOGICAL SOCIETY AND THE AMERICAN ASSOCIATION.

By WARREN UPHAM, St. Paul, Minn.

The forty-fifth meeting of the American Association for the Advancement of Science was held in Buffalo, N. Y., under the presidency of Prof. Edward D. Cope, August 22-29, 1896, this being the fourth meeting of the Association in Buffalo, with intervals of ten years. The enrolled attendance was 330, from a total membership (including fellows) of about two thousand. At this meeting 110 new members were elected;

*G. H. Williams: Amer. Jour. Sci., 3, vol. 44, p. 486; Dec., 1892.
F. Bascom: Jour. of Geol., vol. 1, p. 821; Nov.-Dec., 1893.

and 83 members were elected as fellows, making the present number of fellows about 875.

For the next meeting, to be held at Detroit, Mich., in August, 1897, Prof. Wolcott Gibbs, of Newport, R. I., is elected president: and for Section E (Geology and Geography), Prof. I. C. White, of Morgantown, W. Va., vice president, and Prof. C. H. Smyth, Jr., of Clinton, N. Y., secretary. This meeting will be held immediately previous to that of the British Association, which next year is to meet in Toronto, Ontario.

The affiliated societies meeting also in Buffalo, in conjunction with the American Association, were the Geological Society of America, August 22, under the presidency of Prof. Joseph LeConte: the American Mathematical Society; the American Chemical Society; the Society for the Promotion of Agricultural Science; the Association of Economic Entomologists; the Botanical Society of America; the Botanical Club of the Association; and the Society for the Promotion of Engineering Education.

The Geological Society of America.

According to a vote previously taken by the Council of the Geological Society, the papers presented before it at this eighth summer meeting were read only by title, and their full reading was deferred to the Thursday sessions of Section E of the Association. Six new fellows were elected, namely, Jose Guadalupe Aguilera, of Mexico: Philip Argall, of Denver, Colo.; Ezequiel Ordonez, of Mexico; Thos. W. Vaughan, of Washington, D. C.; Henry S. Washington, of Locust, N. J.; and George H. Ashley, of San Bernardino, California.

It was voted to hold the next winter meeting of this Society in Washington, D. C., on Tuesday to Thursday, Dec. 29-31.

Geological Excursions.

Several excursions, for specialists in different branches of geology, were made before the meetings. One, extending over several days, under the guidance of Prof. C. S. Prosser, had for its object the examination of the stratigraphy and paleontology of the rock formations of western New York in the neighborhood of Syracuse, Rochester, Mt. Morris, Portage Falls, and westerly to Buffalo. Another excursion, for observations in petrography, spent a week in the Lake Champlain valley and in the Adirondack mountains, under guidance of

Profs. J. F. Kemp, C. H. Smyth, Jr., and H. P. Cushing. A third excursion, devoted to economic geology, was led by Dr. F. J. H. Merrill, examining the salt and cement works, gypsum mines, and stone quarries, in the region of Syracuse and westward. Lastly, an excursion for the field study of the moraines, former glacial lakes, and their shore lines and outlets in western New York, was under the direction of Prof. H. L. Fairchild.

The addresses of the vice presidents of sections were given on Monday, August 24; and the four following days were allotted to the reading of papers in the several sections. On Thursday afternoon a considerable number of the geologists visited the very interesting section of the Hamilton beds on Eighteen Mile creek. Finally, on Saturday nearly four hundred members and friends of the Association visited the Niagara falls and gorge. They went north along the Canadian side by the electric railway near the edge of the precipice overlooking the gorge, crossed the river at Lewiston, and returned by the new railway along the bottom of the gorge on the New York side. The electric power for these railways, besides much more used in Buffalo, is supplied by the diversion of a small part of the river above the falls. A geological party further devoted the early part of the following week to field observations of the Niagara gorge, the Whirlpool, and the course of the drift-filled preglacial valley from the Whirlpool northwesterly to St. David's, the depth of which it is proposed to test by borings.

Honor to Prof. James Hall.

In Section E, of which Prof. Ben. K. Emerson was vice president, and Prof. William North Rice was secretary (in the absence of Prof. A. C. Gill, the secretary elect, in Greenland), Wednesday afternoon was given to a very impressive series of addresses commemorative of Prof. James Hall's completion of sixty years of service in the Geological Survey of New York. Such an unprecedented record as his is certainly entitled to the cordial and most graceful recognition which, upon this occasion, it received. The usual audience attending the sessions of Section E was largely supplemented by prominent members from other sections, as well as by eminent citizens of the city of Buffalo.

Professor Hall, who had traveled from San Francisco to be present at this meeting, was addressed by vice president Emerson, on behalf of the Association, and by Prof. Joseph Le Conte for the Geological Society. Nothing could have been more graceful than the earnest and well chosen expressions of these men, briefly portraying the vast obligations of the present generation of geologists to the labors of the venerable scientist. In reply to these addresses, Prof. Hall gave a hasty sketch, not so much of his attainments in science as of the beginnings of his work, its difficulties, embarrassments, and triumphs.

Of particular importance was his reference to the origin of the Association of American Geologists, the parent body of the American Association. The four geologists of the New York survey, feeling the importance of testing their results by comparison with those obtained in other states, resolved, in the autumn of 1839, to enter into correspondence with other working geologists for the purpose of organizing a geological association with this for its chief aim. Initiatory action was taken in the home of Dr. Ebenezer Emmons in Albany, and its outcome was the calling of a meeting at Philadelphia, which took place in April, 1840, whence came the Association of American Geologists. In 1842, at the Boston meeting of that Association, the naturalists asked to be admitted to the society, and in conceding to this proposition the name of the body was changed to "Association of American Geologists and Naturalists." At a later date the chemists and physicists also begged admission, and the name of the society was changed to its present form.

After the remarks by Prof. Hall, a forcible and eloquent address was delivered by Dr. W J McGee, entitled "James Hall, Founder of American Stratigraphic Geology:" and a paper on Prof. Hall's early work in the Geological Survey of the Fourth District of New York, especially noting its influences upon geological science, was read by Dr. John M. Clarke, assistant state geologist. Other speakers further referred to Prof. Hall's labors from various view points: Dr. J. F. Whiteaves, for the Canadian Geological Survey; Hon. T. Guilford Smith, for the State of New York and the Regents of the University: Prof. William H. Niles, for the Boston Society

of Natural History; Prof. J. J. Stevenson, of New York City, in a strain reminiscent of the great personal sacrifices made by Prof. Hall to insure the continuance of his investigations, and of the important personal influence exerted by him in the training of geological workers; and Prof. E. O. Hovey, recalling his own early experiences with the now venerable man. These proceedings, which were exceedingly gratifying to all present, were closed by very happy words from the vice president.

PROF. EMERSON'S ADDRESS.

The address of the vice president in Section E, entitled "Geological Myths," traced the origin and history of several myths which arose from geological events and conditions, including the Chimæra, which had reference primarily to a burning gas spring; Niobe, whose legend was suggested by the drip of waters from the limestone roof above an ancient colossal bust carved in the living rock on the side of a valley near the present city of Smyrna; Lot's wife, referring to columnar cliffs, spared in the subaerial erosion of the wall of salt and gypsum-bearing marls of Kashum Usdum, adjoining the southwestern shore of the south part of the Dead sea; and the traditions of a universal flood, the origin of which was thought by the speaker, following Suess, to be explainable by the coincidence of a great storm and an earthquake wave at the mouth of the Euphrates. This address is published in full in Science for September 11, 1896 (new series, vol. IV, pp. 328–344).

LECTURES BY PROFS. SPENCER AND COPE.

Two public lectures, complimentary to the citizens of Buffalo, were given on Wednesday and Thursday evenings, each being accompanied with lantern illustrations. The first was by Prof. J. W. Spencer, entitled "Niagara as a Time Piece." His explanations of the high shore lines around the great Laurentian lakes as of marine formation, and his computations of the duration of Niagara falls, belonging to the Postglacial period, as 32,000 years, presented in this lecture, had appeared in the AMERICAN GEOLOGIST for November, 1894 (vol. XIV, pp. 289–301), and in Appleton's Popular Science Monthly for May of the present year.

The second lecture, by Prof. E. D. Cope, based on his own explorations and those of Mr. H. C. Mercer, was entitled "The Results of Cave Explorations in the United States, and their Bearing on the Antiquity of Man." A part of the discoveries thus presented, showing man to have been contemporary in Tennessee with the Megalonyx, a gigantic fossil sloth, was published by Mr. Mercer in the American Naturalist for last July (vol. xxx, pp. 608–611, and a plate), together with notes of Prof. Cope's earlier cave researches.

TITLES AND ABSTRACTS OF PAPERS IN SECTION E.

Forty-two papers were presented in Section E (Geology and Geography), of which the following are titles, in their order on the programs of the sessions. For many of the papers abstracts are also added, as kindly supplied by the authors, or shorter notes from correspondents at the meeting. Among these Prof. C. W. Hall of Minneapolis, Minn., Dr. John M. Clarke of Albany, N. Y., Prof. E. W. Claypole, of Akron, O., and Mr. F. B. Taylor, of Fort Wayne, Ind., press secretary of Section E, deserve especial mention and thanks, both for notes of papers and for portions of the foregoing pages. In a few instances the notes are derived from the report of this section by Prof. W. N. Rice in Science for September 18 (pp. 382-388).

1. Notes on the Artesian Well sunk at Key West, Florida, in 1895. EDMUND O. HOVEY. This well has a depth of 2,000 feet, and samples of the borings were taken, under the direction of Prof. Alexander Agassiz, at intervals of 25 feet through the whole depth. The author's microscopical examination shows the entire section to be nearly pure limerock. It is a typical oölite at the surface and at 25 feet below. Beneath that depth most of the samples indicate a fine or coarse, more or less loosely compacted calcareous sandrock, relieved somewhat by beds or masses of dense or porous limestone. Small bits of oölite or loose ovules are present in about half of the samples, indicating a shallow origin for much of the material. The most solid rock of all passed through came from the depths of 50 to 175 feet.

The most peculiar petrographic feature is the presence in all the samples except three of a small amount of quartz. This varies from the merest trace up to a very noticeable proportion, and is of two kinds: the most abundant is extremely fine-grained, angular or crystallized, and perfectly limpid; the other kind consists of scattered grains, well rounded by abrasion, and much larger than the first.

Organic remains which preserve sufficient character for reference even to their class are not numerous, except in a few of the samples. For the most part minute forms are indicated by the fragments. Taken as

a whole, there are more bits of lamellibranch shells and casts of the interior than anything else in the referable fragments; next to these in point of numbers come the tests of foraminifers; then follow echinoderms, corals, bryozoans, and gastropods. Although the foraminiferal genus *Orbitoides* does not seem to be represented in the samples from depths above 900 feet, there seems to be no particular change in the rock, in ascending order, until a marked transition appears between the samples from 700 and 675 feet.

In view of these facts the author is inclined to place the approximate upper limit of the Vicksburg beds of the Eocene in this well at 700 feet below the surface. The lower limit of the Vicksburg may not have been reached. *Orbitoides* seems to be the predominating foraminifer down to 1,450 feet. Between that depth and the next below there is a decided change in color, and, while *Orbitoides* does not entirely disappear at once, two conical forms referred to *Textularia* become much more numerous. Below 1,875 feet *Orbitoides* seems to be absent.

Above 700 feet the material was so comminuted, probably by the drill, that it seems impracticable to differentiate the Miocene and Pliocene. The massive limestone at 50 feet may, however, mark the approximate upper limit of the Pliocene.

This paper was discussed by Profs. LeConte, Hitchcock, Stevenson, and Rice.

2. *The Hydraulic Gradient of the Main Artesian Basin of the Northwest.* J. E. TODD. After giving a brief statement of the extent and attitude of the Dakota sandstone formation and the general distribution of the wells deriving their waters from it, attention was directed especially to the remarkable fact that, when reliable readings of closed pressure are compared, there appears to be a quite regular decline in the pressure hight from west to east, which may be compared to the hydraulic gradient of a stream. The most complete series yet obtained is from Sheridan, in Wyoming, to Marshall, in Minnesota, as shown by the following table.

LOCALITY.	Miles from the east line of South Dakota.	Pressure hight in feet above the sea.
Sheridan, Wyo	515 West.	About 3,700
Belle Fourche, S. Dak	360 "	3,030
Pierre, S. Dak	192 "	1,854*
Highmore, S. D	150 "	1,928
Miller, S. D	127 "	1,817
Huron, S. D	91 "	1,670
Iroquois, S. D	71 "	1,638
Marshall, Minn	33 East.	1,360

The descent of the gradient eastward averages somewhat more than four feet per mile. Between Kimball and Mitchell, S. Dak., on the latitude of Chamberlain, it is ten feet per mile.

*The pressure hights at Pierre, Harold, and some other localities, are too low, probably because of subterranean leakage or derivation from different strata.

From north to south the gradient is almost horizontal between Orient and Armour, S. Dak., about 1,875 feet; but in the James river valley, although it is nearly constant from Ellendale to Huron, about 1,700 feet, it drops farther south to 1,330 feet at Mitchell, and rises again to over 1,500 feet at Tripp.

The explanation considered most satisfactory is that given by Upham in the AMERICAN GEOLOGIST for October, 1890 (vol. VI, pp. 211–221), referring the eastward and southward decline in pressure to leakage from the Dakota sandstone along its eastern edge in Nebraska, Iowa, and Minnesota. It was suggested that actual irregularities of the pressure gradient may result from a complex arrangement of the water-bearing stratum, from inequalities in the leakage on the southeast and east, and from variations in the fineness or porosity of this sandstone. In conclusion, more careful measurements of the closed pressure of the artesian wells of the Northwest were recommended.

3. *The true Tuff-beds of the Trias, and the mud enclosures, the underrolling, and the basic pitchstone of the Triassic Traps.* B. K. EMERSON. This paper gave many interesting notes of field observations of the Triassic belt in the lower part of the Connecticut river valley. It was discussed by Dr. M. E. WADSWORTH, who found striking resemblances to what he had observed in the copper-bearing region of lake Superior. Prof. Rice reports it as follows: "In some localities the broken surface of the extrusive trap sheets, with the calcareous or arenaceous deposits mingled with the trap, has been rolled under in the onward flow of the trap, so that the same phenomena appear both at the top and bottom of the trap sheet. In certain localities the wet mud of the estuary bottom, over which the trap sheet flowed, has risen up into the trap, presenting an appearance very similar to that of true tuff beds. In these cases portions of the mud have been metamorphosed into a quartzite, and portions of the molten material of the trap, chilled by the ascending currents of mud and water, have solidified into a pitchstone or tachylite." The sections and quarries most notably showing these conditions are in Greenfield and Holyoke, Mass., and in Meriden, Conn.

4. *Volcanic Ash from the North Shore of Lake Superior.* N. H. WINCHELL and U. S. GRANT. Published in the preceding pages.

5. *The "Augen Gneiss," Pegmatite Veins, and Diorite Dikes at Bradford, Westchester county, N. Y.* LEA McI. LUQUER and HEINRICH RIES. To be published in the AMERICAN GEOLOGIST.

6. *The Tyringham (Mass.) "Mortise Rock," and pseudomorphs of Quartz after Albite.* B. K. EMERSON. Specimens were exhibited, in which the quartz has minute cavities due to crystals of salite dissolved out. Pseudomorphic quartz fills delicate casts of albite and cleavelandite, showing striæ and luster.

7. *The Succession of the Fossil Faunas in the Hamilton group at Eighteen Mile creek, N. Y.* AMADEUS W. GRABAU. The sections exhibiting the Hamilton beds, underlying the Genesee and Portage series, at Eighteen Mile creek (tributary to lake Erie about eighteen miles southwest of Buffalo) are situated between the L. S. & M. S. railway

bridge and the mouth of the creek. There are eight sections, averaging 70 feet in hight and ranging from 200 to 2,000 feet in length. The following subdivisions are recognized:

"Moscow" shales	17 feet.
Encrinal limestone	1½ feet.
Lower shales	40+ feet exposed.

The "Conodont" bed of Hinde, which that writer placed near the top of the Hamilton, is referred to the base of the Genesee.

The lowest beds exposed are the "Trilobite beds," in which *Phacops rana* and *Dalmanites boothi* occur very abundantly. *Stropheodonta nacrea* is another characteristic species in these beds, which may be traced eastward along the lake shore to Hamburg-on-the-Lake, where the base of the Hamilton is exposed about seven feet below them.

Eight feet below the Encrinal limestone is the *Athyris spiriferoides* bed, where this fossil occurs almost to the exclusion of every other. One foot below the Encrinal limestone is the *Stropheodonta demissa* bed, the richest fossiliferous level in this region. Sixty-two species are obtained from this bed, which is only about four inches thick.

The most characteristic fossil of the Lower shales, which may properly give its name to their fauna as a whole, is *Spirifer mucronatus*, of the ordinary broad-winged variety.

The Moscow shales (so-called, though they do not correspond to the shales at Moscow) contain two distinct faunas, separated by barren beds 7 or 8 feet thick, near the center of which, however, occurs a thin bed with *Orbiculoidea media*. The fauna of the lower part of the Moscow shales is called the *Spirifer consobrinus* fauna; that of the upper part is the *Spirifer tullius* fauna.

A comparison of this entire series with the faunal subdivisions of the Hamilton of Ontario, as given by Calvin in an early number of the AMERICAN GEOLOGIST (vol. I, pp. 81-86, Feb., 1888), shows an interesting correspondence. Of the three subdivisions made by him, the lower is characterized by the ordinary form of *Spirifer mucronatus*, and in its association of fossils resembles the fauna of the Lower shales at Eighteen Mile creek.

In the Genesee valley the physical conditions, and the consequent faunal associations, were very different. The Lower shales, having a thickness of 90 feet or more in the Livonia salt shaft, contain few fossils, and these are mostly unlike those found at Eighteen Mile creek: but the Encrinal limestone is practically identical. The greatest difference is found between the Upper or Moscow shales of the two localities. These at Livonia are more than 300 feet thick, and the association of fossils recalls that in the Lower shales of the sections at Eighteen Mile creek. This points to an eastward migration of that fauna, following the changes in physical conditions.

Under the guidance of Mr. Grabau, a party numbering nearly a hundred visited Eighteen Mile creek on Thursday afternoon, examining each of its eight sections here described.

8. Development of the Physiography of California. JAMES PERRIN SMITH. This paper was illustrated by a stereopticon view of a relief map. The present contour was ascribed mainly to Tertiary and Quaternary uplifts and consequent erosion.

9. Synopsis of California Stratigraphy. JAMES PERRIN SMITH.

10. Ancient and Modern Sharks, and the Evolution of the Class. E. W. CLAYPOLE. The Devonian cladodont sharks, recently discovered in northern Ohio by Dr. Clark and described by the author in a series of papers in the AM. GEOLOGIST, exhibit great differences from their modern representatives; and this paper presented some suggestions on the probable ways in which these differences have been evolved.

11. Observations on the Dorsal Shields in the Dinichthyids. CHARLES R. EASTMAN. The object of this paper was to trace the genetic relationship between the typical dinichthyid genera of America and the European coccosteids. Attention was called to the fact that valuable systematic characters are afforded by the configuration of the median dorsal plate in the Coccosteidæ. In particular it was maintained that a large, excavated posterior process is common to dinichthyid but absent in coccosteid genera; and, furthermore, that the coccosteids may be arranged in a definite series according to the progressive modification of the inferior ridge and terminal process of the dorsal shield. This series includes the genera *Coccosteus*, *Homosteus* and *Heterosteus*, together with certain forms leading up to *Dinichthys*. the affinities of which do not seem to have been properly understood. Among the latter may be mentioned the so-called *Pelecyphorus* of Trautschold, *Asterolepis bohemica* of Barrande, *Coccosteus* sp. (=*D. livonicus*) of Pander, and one or two as yet undescribed forms from the Devonian of the Eifel district; all of which are shown, by their possession of a characteristic terminal process, to belong to the dinichthyid instead of the coccosteid group.

The series of European dinichthyids, starting with Pander's *D. livonicus*, may be traced from its probable origin in northern Europe southward and eastward into Bohemia and Russia, westward into central Germany and Belgium. and thence across the Atlantic into the United States and Canada. At least one species (*D. tuberculatus*) is intercontinental in distribution. Westward the divergence was so great as to give rise to no less than fifteen species of *Dinichthys*, besides a number of related genera; and the most remarkable fact concerning them is their prodigious increase in size. The function of the posterior process was assumed to be in relation with swimming; and with its gradual development, increased locomotive facilities were acquired. The known predacious habits of *Dinichthys* afforded it the necessary competition, and its better equipment for swimming enabled it to attain the ascendancy over the original coccosteid stock. Its ultimate supremacy in Devonian seas is witnessed by its size, its abundance and distribution, and its range of variation.

Incidentally a slab was exhibited on which was preserved the entire ventral armor of a *Dinichthys* from the Portage shale near Buffalo, dis-

covered some time previously by Mr. F. K. Mixer. All the elements were retained in their natural position, so that there can be no longer any doubt as to the reconstruction of the under surface of this genus. The specimen recalls the somewhat similar one of *Holonema* exhibited by Prof. H. S. Williams at the Indianapolis meeting of the Association in 1890, these two being the only instances known where the ventral plates of the respective genera are preserved *in situ*.

12. *The Discovery of a new Fish Fauna, from the Devonian rocks of Southwestern New York.* F. K. MIXER. The oldest remains of fishes from this region were discovered in the Corniferous limestone, and were noticed in the Bulletin of the Buffalo Society of Natural Sciences (vol. v, p. 84, 1888). These remains consist of the spines and teeth of selachians, similar to those described by Dr. Newberry from the Devonian of Ohio.

When we come upward to the rocks of Hamilton age, we find that nothing in the class of fishes has been heretofore described, so far as known to the writer, from this region. The remains now discovered in this formation consist of determinable plates of dinichthyid fishes.

The next horizon, in ascending geological sequence, to reveal fish remains is that of the Black shales in the Portage series. From these shales a plate of a small Dinichthys, and two ganoid fishes, have been described. More recently the mandibles of a dinichthyid, besides more perfect remains of these ganoids, have been discovered in these shales.

13. *Interglacial change of course, with gorge erosion, of the St. Croix river, in Minnesota and Wisconsin.* WARREN UPHAM. (Read by Prof. C. W. Hall.) An outline of a lecture at Taylor's Falls, Minn., substantially the same as this paper, was given in the AMERICAN GEOLOGIST for last April (p. 260). The Aftonian interglacial epoch in southern Minnesota, as indicated by the erosion of the St. Croix Dalles, was probably longer than the Postglacial period. From the corresponding interglacial valley of the Mississippi river west of Minneapolis, filled with drift but marked by a series of lakes, Prof. N. H. Winchell. in the AM. GEOLOGIST (vol. x, pp. 69-80, with map and sections, and p. 302, Aug. and Nov., 1892), estimates the time required for its erosion (since named by Chamberlin the Aftonian epoch) as about 15,000 years, which seems well accordant with the interglacial erosion of the St. Croix valley.

14. *The Preglacial Cuyahoga Gorge in Cleveland, Ohio.* WARREN UPHAM. (Read by Prof. G. F. Wright.) This paper is based on information supplied by Mr. S. J. Pierce of Cleveland, derived chiefly from deep well borings which have been made during several years past under the direction of Mr. F. S. Gilbert, contractor, also of Cleveland, showing that the preglacial Cuyahoga valley in its last eight miles, passing through Newburg and Cleveland, has a depth of 350 to 470 feet below the surface of lake Erie. The deepest previously published well section in drift at Cleveland was that of the Standard Oil Company, recorded in the reports of the Geological Survey of Ohio by Newberry, which, situated near the mouth of Kingsbury run, reached the bed rock of shale 228 feet below the level of the river and lake. Even that

depth of drift revealed a very interesting preglacial valley and different conditions of topography and drainage from those of the present day; for the greater part of lake Erie, as is well known, is only about 80 feet deep, while its maximum depth, apparently in an old river valley now covered by the lake, is only 210 feet. It was also ascertained by Newberry, from borings for oil, that where the Cuyahoga river enters Cuyahoga county, about thirteen miles from the lake Erie shore at Cleveland, the bottom of the preglacial gorge is 220 feet below the present river, or about 175 feet below the level of the lake.

By inspecting the additional well records, it is found that, within the area of the city of Cleveland, shown in figure 1, the line of maximum

FIG. 1. MAP OF THE CITY OF CLEVELAND, SHOWING ITS AREAS OF GLACIAL AND VALLEY DRIFT. (Reduced from a plate in the Bulletin of the Geol. Soc. of America, vol. VII.)

depth of the old valley lies near its east side and runs toward the north-northeast, passing near to the Forest City park, the intersection of Giddings and Euclid avenues, and Gordon park. Where the preglacial Cuyahoga gorge enters this county, it had already attained a depth of 175 feet below the present lake; in the northern edge of Independence township, eight miles from the lake, its depth below the same plane is 333 feet, without there reaching the bed rock; at Giddings and Euclid avenues, its depth is at least 340 feet; a half mile farther north, it is 390 feet, if not more; and at Gordon park it is known to exceed 470 feet, — all being depths below lake Erie.

Because of the greater expense of boring in the drift than in the underlying shale, the depth to the base of the drift has been carefully determined; but the succession of diverse drift deposits, and their respective thicknesses, have not been so noted. Concerning the characters of the drift, Mr. Gilbert states that, beneath the superficial Cuyahoga

delta sand and gravel, usually 10 to 20 feet deep, a considerable thickness of stony and gravelly clay or till is passed through, with occasional enclosed beds of stratified gravel and sand; but that the lower portion of some of the deep drift sections consists chiefly of sand and gravel, resembling those of the present lake beaches. In the till of the well at the public square he bored through a log fully two feet in diameter, thought to be oak, at the depth of 125 feet. In this well a stratum of seven feet of very fine quicksand lay immediately upon the shale, at the depth of 205 feet from the surface; but in some other deep wells the lowest drift deposit is clay, probably till.

The deep preglacial valleys of the Cuyahoga and Rocky rivers, tributary to the basin which now holds lake Erie, testify, with many other similarly deep and drift-filled preglacial river courses throughout the interior of our country, that immediately before the Ice age this continent was uplifted much above its present altitude, giving steeper gradients and increased power of erosion to the streams. The duration of the uplift, however, was not geologically long; else the narrow gorge of the Cuyahoga would have become a wide valley, and, on the borders of the continental plateau, the fjordlike continuation of the Hudson and other rivers, and the northern and Arctic fjords, would have been widened to mature valleys, with extensive lowland plains and gently sloping sides.

Such great depth of erosion by the preglacial Cuyahoga river shows that the Tertiary and Quaternary river of the lake Erie basin had its course on a land surface which is now covered and raised, probably for the greater part from 200 to 400 feet, by the deposition of glacial and modified drift during the Ice age. The topographic irregularities of the preglacial Erie valley are thus largely enveloped by the drift, which forms a very level expanse beneath the shallow lake. The beds of coarse gravel contained in the till near its base, as in the Standard Oil Company's well, indicate fluctuations of the glaciation in its early stages, with free drainage conditions, the altitude being greater than now, and the lake area not yet depressed to be a closed basin.

15. A Revision of the Moraines of Minnesota. J. E. Todd. This paper presented first a map of the moraines of northern Minnesota as interpreted and mapped by Mr. Upham in the Twenty-second Annual Report of the Minnesota Geological Survey, in which the northern moraines, in the series of twelve found in this state, are represented as extending in general from east to west across that district, having been formed successively during a motion of the ice-sheet principally from the north. The following objections were urged against this interpretation.

1. It assumes that latitude had more to do with the ice movement than altitude, and that topography had little effect on the movements of the ice-sheet. On the contrary, in the case of the present glaciers of Alaska and Greenland, as well as of the Dakota, Iowa, and Wisconsin lobes of the ancient ice-sheet, it appears that, at least in the zone of ablation, glacier lobes, like streams, flow farthest in the valleys. It

claims that the ice retired from the lake Superior basin and the Red river valley earlier than from the highlands about lake Itasca and the Mesabi range. The abrupt rise of more than 1,000 feet from lake Superior to the highlands on the north is supposed not to have affected the direction of the so-called Leaf Hills and Itasca moraines. The Mesabi moraine is represented as descending 200 feet from the watershed north of the Mississippi to Red lake with a retreating angle, instead of an advancing front which it should have according to analogy with the previous lobation farther south.

2. It does not represent the ice-sheet as retiring in the proper direction to explain the formation of the early stages of lake Superior, nor is it in harmony with the glacial movements of recession producing the stages of lakes Warren and Algonquin.

3. It does not agree with the observed directions of striæ, particularly those about Duluth and Carlton, Minn., which bear mostly W. S. W., and those on the upper portion of the Big Fork river, which bear largely westward or perhaps eastward.

4. It does not harmonize with the observed distribution of boulders. The basin of the upper Mississippi lacks limestone boulders, while they abound to the west and north of its watershed. Moreover, Mr. J. E. Spurr, in the same Twenty-second Annual Report, states that in northeastern Minnesota the moraine correlated with that of the Leaf Hills by Upham, as also the drift north of it for some distance, has clearly been derived from the northeast or east.

5. It disagrees with several morainic areas more recently observed by the author, notably with a moraine belt passing south of Turtle River lake and Turtle lake and curving south across Grant creek and west of Schoolcraft river into Hubbard county, and with another which passes north of Cass lake, thence across the Mississippi, and along the southwest side of lake Kabecona and south of Leech lake. These moraines are sufficient to indicate a north and south trend over this portion of the state.

In view of these and other facts, a new mapping of the moraines in north central Minnesota was offered, referring them to two great lobes of the ancient ice-sheet, a shorter one moving southwest through the lake Superior basin, and a longer one moving around this from the northeast to the west and southwest. In their recession, these lobes formed successive slender and more or less curved reëntrant angles, producing interlobate moraines, one arm of each being formed on the west side of the Lake Superior lobe, and the other arm along the east side of the Red River lobe. The apex of this angle advanced toward the northeast until it grew into a slender moraine, probably traceable along the Mesabi range. The courses of the moraines, according with this view, were indicated in detail by a map.

16. Notes on certain Fossil Plants from the Carboniferous of Iowa. THOMAS H. MACBRIDE. Microscopic slides, showing sections of the stems of a *Sigillaria*, probably *S. vascularis* Binney, from the Des Moines beds of the Iowa Carboniferous, were exhibited. The woody

tissue is of two types, that which constitutes an inner medullary cylinder, and that which forms the wood proper of the stem. The latter surrounds the medullary structures, is radiately cleft by abundant medullary (?) rays, and gives every evidence of having been exogenously developed. The woody tissues are constituted, as in the conifers, of what may be called tracheides, but are unlike conifers in that the tracheides are marked by the scalariform mode of wall-structure and not by bordered pits. All this is confirmatory of Binney's researches. As to what constitutes the true medulla, the author argued that it must have consisted of loosely constructed and early decadent parenchyma, whose individual cells are no longer identifiable.

17. Origin of the High Terrace Deposits of the Monongahela river. I. C. WHITE. These terraces along a distance of more than a hundred miles, extending at least from Weston, W. Va., to Geneva, Pa., are attributed to deposition in slack water, amounting to a lacustrine condition. They are practicaly level, while both the rock shelf and the present rock bed of the valley have a regular descent downstream. The clay deposits of the upper terrace level (about 1,000 feet above the sea) are, in places, as much as sixty feet thick, and contain multitudes of perfectly preserved leaves. Most of the species are of trees and other plants which still occupy the same region; but at least one is now restricted to the region north of the great Laurentian lakes, thus pointing to the influence of glacial conditions in depressing the temperature as far south as West Virginia. The ice-dammed lake in which these terrace deposits were formed is named lake Monongahela. Its formerly level plane is now 1,000 to 1,100 feet above the sea.

To account for the slack water at this level, the author now adopts the theory advocated by Hice and Foshay and by Chamberlin and Leverett, that the original drainage of the Monongahela basin passed northward, through the Big Beaver and Mahoning valleys, to the lake Erie valley. But this direction of the drainage was before the ice-sheet extending from the north reached the watershed of the present Ohio. Then it was reversed, and the streams from the ice melting and from rains rapidly cut through the cols which separated the headwaters of the various branches running from the flanks of the Allegheny uplift, thus forming the new stream which the Ohio essentially is. The suggestion of Chamberlin is accepted, that there was a col south of Wheeling to be cut down, and it is thought to have been sufficiently high at first to form the barrier that dammed the water up to the level of the Monongahela terraces, which therefore are now so explained without the help of the Cincinnati ice dam, although that may have been influential to produce terraces farther down the valley. As to the time required for the production of the present Ohio valley, by the erosion of cols, it was inferred that the ice-sheet may have taken thousands of years in slow extension from the watershed of the Ohio to its farthest bounds, while the rocks below Wheeling are very soft and would have been rapidly worn away.

In the ensuing discussion, Prof. G. F. WRIGHT and Mr. G. K. GILBERT concurred with the author's conclusions.

18. The Making of Mammoth Cave. HORACE C. HOVEY. The bibliography of the Mammoth Cave of Kentucky includes more than four hundred citations, and many of the authors and observers ascribe the origin of the cave to earthquakes aided by the grinding agency of whirling water freighted with sand and pebbles. This latter theory for the formation of the pits and domes is held by Dawkins and Shaler, as well as others of note. The present author, on the contrary, after having examined every pit and dome in this immense cavern, believes that they were all made by solution and decomposition. The limestone from which the cave was excavated shows slight signs of seismic disturbance; and the streams have accomplished little through abrasion or erosion.

In company with Dr. R. E. Call, the author has measured nearly all the large pits and domes, in gathering details for a new guide-book of the cave. The Bottomless Pit is 105 feet deep. Gorin's dome is 105 feet deep from the top, and 88 feet from the "window," where tourists usually look into it. Garvin's pit is 95 feet deep; and Scylla and Charybdis are 89 feet deep. The Maelstrom is 98 feet deep. These measurements were taken with the utmost care and can be relied upon as correct.

19. The Colossal Cavern. HORACE C. HOVEY. There are said to be five hundred caverns in Edmonson county, Kentucky, so that the finding of a new cave in that region need not surprise anyone. But the Colossal Cavern, discovered in July, 1895, by Mr. Pike Chapman and owned by Mr. Hazen W. Proctor, is really a great discovery. It is only about four miles from the Mammoth Cave, which it resembles in many of its features. The entrance, however, is down through an orifice at the top of a dome. After descending 66 feet, the bottom is found to be a mass of debris. Thus the visitor descends dome after dome, by means of ladders, until he stands at a point 240 feet below the place of entrance. These domes are very magnificent. The crystal rosettes (oulopholites) are extraordinarily delicate and superb. Never having been disfigured or blackened by torches, they are white as snow and sparkle brilliantly under the magnesium light. There is said to be a large body of water in this cave. Explorations by strangers are not allowed, as the effort is being made to find some more convenient way of access through some other known cavern.

20. James Hall, Founder of American Stratigraphic Geology. W J MCGEE.

21. Professor Hall and the Survey of the Fourth District. JOHN M. CLARKE.

22. Sheetflood Erosion. W J MCGEE. Papagueria (the land of the Papago Indians), lying in southwestern Arizona and western Sonora, is a distinct province or subprovince presenting many interesting geologic and geographic features. It is hot and arid; its waterways are few and small and never reach the sea, so that degradation and aggradation are complete within it: it is an area of broad, undulating plains, separated

by scattered sierras which are notably rugged; and since the general conformation of the province was shaped it has suffered southwestward tilting whereby the southwestward flowing streams have been stimulated and the northeastward flowing streams paralyzed to the extent that the divides are migrating and no longer coincide with the dominant topographic features. One of the striking characteristics of the province is the ruggedness of the mountains and the sharpness with which they rise from the flat-lying plains; a still more striking feature is the structure of the plains—they consist of the planed edges of strata similar to or identical with those composing the mountains, veneered with a thin sheet of mechanical debris, and are manifestly produced by widespread planation extending over the greater part of the province, i. e., the entire area except the central portions of the valleys, which are deeply lined with alluvium, and the scattered sierras which are remnants of an ancient plateau.

On studying the process and agencies of erosion, it is found that the chief agency is storm-water and that active erosion is limited to a few consecutive hours or days during the semi-annual, annual, or more widely separated storm-freshets. When such freshets occur the waters are quickly charged with mechanical debris, the products of past storms or of inter-storm disintegration; the overloaded freshets push slowly over the vast plains in sheets of muddy water; and whenever the viscid sheet begins to segregate in a stream its velocity and hence its transporting power immediately increase until it is overloaded more heavily than before, and within a few yards begins to build up a delta by which its velocity is checked and its volume redistributed; so that the ultimate tendency of the flood is to continue in a sheet until the waters are lost through evaporation and absorption. Thus the characteristic form of water-flow is not in streams, but in sluggishly moving sheets which may be called *sheetfloods*; these are amply supplied with rock matter which is mechanically disintegrated rather than chemically reduced, and which is thus an efficient eroding substance; and throughout most of the region the tendency of the storm waters is not to carve valleys, but to plane broad belts two to twenty miles or more in width. It seems certain that this distinctive agency has produced the distinctive conformation and structure of the province.

23. *Glacial Flood Deposits in the Chenango Valley.* ALBERT P. BRIGHAM. The aqueo-glacial or modified drift deposits found in the Chenango and Oriskany valleys from Deansville, near Utica, to Binghamton, N. Y., are described as kames, eskers, kame terraces, frontal terraces, and valley trains, in this terminology following Salisbury. True till is found only on the main hill slopes. The kame terraces are deposits marginal to ice tongues, being the same as the lateral moraine terraces of Gilbert. The frontal terrace is associated with kames, and in some cases is shown to be a true delta deposit. It is a frontal apron of the valley type, and is closely related to the sand plains of Davis and others. Massive fine clays, underlying the valley train gravels, show lacustrine conditions of long duration, whose history is not yet deter-

mined. It is believed that the ice retired with relative (though not absolute) rapidity in this region, with several pauses, especially at the southern rim of the Mohawk basin. The observations do not indicate deep and powerful floods in the Chenango valley during the progress of the final glacial melting; and an essentially sectional manner of valley train deposition is here emphasized.

24. Origin of Conglomerates. T. C. HOPKINS. The source and the manner of accumulation of the coarse material in the heavy beds of conglomerate in different parts of this country present some difficult problems. This is especially true of the conglomerate at the base of the Coal Measures; and in few districts is this conglomerate farther removed from an apparent source than in Indiana. The author showed, however, that a considerable portion of this material in Indiana, possibly all of it, came from the underlying limestone of Lower Carboniferous age, being derived from the segregated chert masses, quartz breccias and geodes contained therein. The evidence in support of the statement is, in the main, the finding of geodes and geodic fragments in the conglomerate, along with chert fragments.

25. Origin of Topographic Features in North Carolina. COLLIER COBB.

26. The Cretaceous Clay Marl Exposure at Cliffwood, N. J. ARTHUR HOLLICK. This outcrop represents the extreme northeastern extension of the formation. It is a bold bluff, some thirty feet high, more or less masked by a talus at the base, and capped by yellow gravel. It is one of the few localities where the fauna of the horizon has been collected to any notable extent, and is the only one, so far as the author is aware, which has ever yielded any of its fossil plants. The material collected consists of poorly preserved molluscs, fragments of crustaceans, leaves, fruit, and branches of plants, and masses of lignite.

The crustaceans are too fragmentary for determination. Among about fifteen species of molluscs, the following were identified: *Pteria petrosa* Conr., *Nemoarca cretacea* Conr., *Cardium ripleyanum* Conr., *Leiopista protexta* (Conr.) Meek, *Inoceramus sagensis* Owen, *Gryphæa vesicularis* (Lam.) Whitf., and *Scalaria hercules* Whitf. All of these had been previously found at or near the same locality.

About twenty-three species of plants were found, three being provisionally referred to gymnosperms and eighteen to dicotyledonous angiosperms, while two are of doubtful systematic position. *Cunninghamites elegans* (Corda) Endl. and *Dammara borealis* Heer are the most abundantly represented. Species recognized as identical with those of the Amboy clays are *Laurus plutonia* Heer, *Salix protæfolia* Lesq., *Myrica fenestrata* Newb., and *Magnolia woodbridgensis* Hollick. The remainder represent either new species or species not before recorded from eastern North America. Some are too fragmentary for more than generic determination. These specimens are of great interest as representing the last phase of Cretaceous land vegetation in this region, the next succeeding sediments being purely marine.

27. *Post-Cretaceous Grade-plains in southern New England.* F. P. GULLIVER. The Jura-Cretaceous peneplain of the eastern United States has been elevated and dissected. The elevation of southern New England was from 150 to 250 feet, causing grade-plains to be developed for one or two hundred miles inland. Afterward the land was again uplifted 100 to 200 feet, and grade-plains were again developed at a greater depth. The land still continued to rise, and trenches were cut below the level of the second lowland grade-plains. Lastly, a slight depression now allows the sea to enter some of the valleys.

28. *The Algonquin River.* G. K. GILBERT. The channel of this Pleistocene river was first observed and named by Spencer in 1888, being then described as the outlet of lake Algonquin. It flowed from the old lake at the site of Kirkfield, Ont., down the Trent valley to lake Ontario. In 1891 Spencer hesitated between this opinion and the view that the Algonquin water was a gulf of the ocean, the relation of its highest plane to the Kirkfield pass being a coincidence. In papers published this year he has adopted the latter theory without reserve.

Last autumn Mr. Gilbert examined the upper course of the Algonquin river from Kirkfield to Fenelon Falls, and traced considerable parts of its lower course, finding everywhere unmistakable channel characters. The Trent drainage valley includes many lakes. In the shorter stream ways between lakes the drift, originally from 20 to 70 feet deep, has been removed for a width of one mile, exposing bare sills of Trenton limestone. In longer stretches of constricted passage the width of the old channel ranges from 1,500 to 3,000 feet, and the bottom is often paved with great boulders. Above Rice lake the channel is divided, one part following the Otonabee, the other Indian river. There is a delta at the estimated position of the Iroquois plane; but, as that is also the plane of Rice lake, the correlation with lake Iroquois is questionable. The old Pleistocene channel does not stop at Rice lake, but continues with undiminished strength to lake Ontario at Trenton.

It follows, (1) that the Algonquin water was a lake, and not a gulf; (2) that during the epoch of the Algonquin river the Niagara drained only the Erie basin; and, (3) that the waning of the ice-sheet opened the upper St. Lawrence valley before it opened the Mattawa valley. (The last inference has been reached also by Taylor from independent data.)

Spencer has traced the Algonquin shore line as it descends from Kirkfield and from the vicinity of lake Simcoe, westward along the south side of Georgian bay and in the Huron basin; and Taylor has recently observed it at Sarnia and Port Huron, where it is not far above the water of lake Huron. I infer (thus agreeing with Taylor's latest and Spencer's earliest opinion) that the outlet of lake Algonquin was diverted by terrestrial deformation from Kirkfield to Port Huron; and it follows that the opening of the St. Lawrence passage and the resulting disappearance of lake Iroquois preceded that diversion. These results have a bearing, not only on the use of the Niagara gorge as a chronometer, but on the comparative geography of the ice-front.

29. The Whirlpool-St. David's Channel. G. K. GILBERT. When Hall and Lyell visited the Whirlpool in 1841 and laid the foundation for its scientific interpretation, they differed notably as to the character of the old channel they discovered. Hall thought it comparatively shallow. My own study, which has been somewhat extended and has included a topographical survey, sustains the view of Lyell.

Hall's opinion was based on the occurrence of rock in the bed of Bowman creek, a tributary of the Whirlpool. Being surrounded by forest, and not having the aid of a good map, he made the easy mistake of supposing Bowman ravine to traverse the middle of the drift mass filling the channel, whereas it really follows the southwest margin; and, where the creek trenches on the side of the buried channel, he thought the bottom was exposed. Claypole and Spencer afterward repeated his observation and inference.

My study also confirms the observations of Lyell and Belt that the drift filling the old channel is visible *in situ* down nearly to the margin of the Whirlpool, instead of being a mere veneer of landslides as reported by Spencer.

The course of the old channel between the Whirlpool and St. David's is now fairly well outlined. The southwest wall has been traced by means of outcrops of Niagara limestone through nearly half its length. The northeast wall is fixed at one point by an outcrop and at a second point by means of two deep wells, one of which penetrates drift only while the other encounters rock.

From a study of the configuration of the Niagara gorge above the Whirlpool, it appears, on the whole, probable that the ancient gorge (whether preglacial or interglacial) ended two or three hundred yards above the Whirlpool; but Pohlman's theory that it extended to the Whirlpool rapids is not disproved.

30. Profile of the Bed of the Niagara in its Gorge. G. K. GILBERT. In the pool between the cataract and the Whirlpool rapid a number of soundings were made by the United States Lake Survey, the greatest recorded depth being 189 feet. At the mouth of the gorge a depth of 96 feet was determined by the same corps. At most intervening points direct measurement is prevented by strong currents. To supplement the soundings, I have made indirect measurements in four places, using a method first suggested by Taylor. At each place the width of the stream and the velocity of the central part of the current were measured. The simultaneous volume of flow was computed from the hight of water at the head of the river, as shown by the United States engineer gage at Buffalo, the computation being based on discharge measurements made some years ago by U. S. engineers, near the International bridge. The depth was then derived by the following formula:

$$\text{Central depth} = \frac{15}{8}\,\frac{\text{Volume}}{\text{Central velocity} \times \text{width.}}$$

The depth thus computed along the Whirlpool rapid was 35 feet; at the outlet of the Whirlpool, 50 feet; opposite Wintergreen flat, 35 feet; and below Foster flat, 70 feet. Some allowance should be made for the

fact that the work was performed in the summer of 1895, when the volume was exceptionally small. The remainder of the profile was interpolated by the aid of comparative studies of the character of the water surface. A depth of about 100 feet is ascribed to the stretches above and below the Whirlpool, each being separated from the Whirlpool basin by a narrow sill: the depth of the Whirlpool is estimated at 150 feet; and a gradual deepening is inferred for all the channel below Wintergreen flat.

In interpreting the profile, features at the Whirlpool are explained by the phenomena of the buried channel, and the depth at the mouth of the gorge by a temporary low baselevel of post-Iroquois date. The shoals at Wintergreen flat and the Whirlpool rapid are correlated with epochs when the discharge of the upper lakes by the Trent and Mattawa valleys left the Niagara river and falls too small and weak for deep excavation.

31. The Niagara Falls Gorge. GEORGE W. HOLLEY. No abstract nor notes of this paper have been received; but reference may be made to this author's interesting little book on Niagara, published twenty-four years ago.*

32. Origin and Age of the Laurentian lakes and of Niagara Falls. WARREN UPHAM. (Read by Prof. C. H. Hitchcock.) Published in the last preceding number of the AMERICAN GEOLOGIST (vol. XVIII, pp. 169-177, with map, Sept., 1896).

33. Correlation of Warren Beaches with Moraines and Outlets in Southeastern Michigan. F. B. TAYLOR. The work reported was begun early in June of this year by Mr. G. K. Gilbert, and was afterward continued by the writer at his request. It was found that the Forest beach, which is the lowest well-marked beach of lake Warren, rises from 83 feet above the level of lakes Huron and Michigan near Port Huron, where Prof. Spencer measured it, to 195 feet at Bad Axe, where it rounds the end of the "thumb" of Michigan (the projection southeast of Saginaw bay). From Bad Axe it passes through Gagetown to Vassar, and then backward to Cass City; thence it runs southwesterly past Juniata and Clio, and thence nearly west to Maple Rapids, about five miles within the head of the Pewamo channel. At Chapin its altitude is about 125 feet. Beyond that place westward the aneroid determinations were not very satisfactory. At Maple Rapids the Forest beach has an approximate hight of 100 feet.

Detailed study of the glacial topography in the region about Bad Axe, Verona Mills, and Ubly, shows that up to about 200 feet the land has a gentle and comparatively smooth slope toward lake Huron. Above is a rugged morainic topography, with the hilltops 250 to 275 feet above the lake. Near Port Huron the Arkona beach, as identified by Spencer, is 116 feet above the lake. But the closest examination of the hills near Verona Mills and Ubly failed to show any trace of shore lines above the Forest beach.

*Niagara: its History and Geology, Incidents and Poetry, with Illustrations. 1872. (165 pages and a map.)

Three well marked channels of abandoned outlet rivers were found crossing the crest of the "thumb" from east to west. These are called the Imlay, Cumber, and Tyre channels, named after villages that are in or near them. The last two have their mouths within a mile of each other near Cass City. The first channel is farther south, extending from near Imlay northwestward to North Branch and probably beyond. This channel lies between the head of the great interlobate moraine on the southwest and a well defined terminal moraine which is the first in a series of three moraines lying between the channel and the present lake shore. The Maumee beach of Spencer (probably the same as the Leipsic beach in Ohio) was traced from Berville into the head of the Imlay channel. The Ridgeway beach, which is the next lower in the Warren series, was traced north and east from Emmett to the west slope of the valley of Black river, which lies between the second and third moraines. The Arkona beach, next below, also passes northward into this same valley. From these localities near Port Huron northerly to the heads of the Cumber and Tyre outlets the valley has not yet been explored. But the fact that the two beaches pass into the valley at the south end, while the two outlets pass out of it at the north end, seems to leave no serious doubt that the beaches connect with those outlets, the Ridgeway with the Cumber, and the Arkona with the Tyre.

It appears, then, that three stages of lake Warren had their outlets westward across the "thumb" of Michigan to the Saginaw valley, and thence westward to the Michigan basin and the Mississippi river; that the Forest or last beach of lake Warren is the only one which passes around the "thumb;" and that this beach passes into the Pewamo channel as the outlet of the lake at that stage. In the Saginaw valley a new beach was found extending westward from Cass City into the Pewamo channel. It lies 20 to 30 feet above the Forest beach, and appears to have been contemporaneous in its formation with the Ridgeway and Arkona beaches. It marks the shore of lake Saginaw, which there stood in front of the waning ice-sheet while the third moraine and the Ridgeway and Arkona beaches were being formed. This has been called the Du Plain beach.

We have then the following five outlets for as many successive stages of lake Warren, namely, the Fort Wayne, the Imlay, the Cumber, the Tyre, and the Pewamo. This paper was illustrated by a large colored map, showing the several beaches, outlets, and moraines.

34. Notes on the Glacial Succession in eastern Michigan. F. B. Taylor. During the author's explorations of the Great Lake region for old shore lines, many notes were taken incidentally on the glacial drift and its various characters. In 1895 three terminal moraines were clearly made out in exploring the eastern coast of Michigan between the strait of Mackinac and Saginaw bay. The work of the present season in the Saginaw valley and on the "thumb" has supplemented that of last year so as to continue the series down to northern Ohio and Indiana, where the moraines had been mapped before by Gilbert and Dryer. If to these we add Leverett's moraines in the valley of the Great Miami

river in southwestern Ohio. we have a perfect and unbroken series marking stages in the retreat of the last ice-sheet from near Cincinnati to the strait of Mackinac.

Beginning at Leverett's most southerly moraine, near Cincinnati, and numbering the series northward, along the central axis of the Great Miami valley, down that of the Maumee, up that of the Detroit and St. Clair rivers, and thence northward along the east shore of Michigan, we find that the fifteenth or Hagenville moraine lies just south of the strait of Mackinac, and that the thirteenth or Huron-Saginaw moraine lies a little back from the shore of Saginaw bay and the south arm of lake Huron. That the first moraine back of the shore in each of these latter valleys is in reality one continuous moraine. bending northward around the "thumb" and marking strictly contemporaneous positions of the ice front, was a subject for proof by observation. This fact was established by a detailed study of the moraines near Ubly. The first moraines of the two valleys join in a right angle near this place, the Saginaw moraine running to the northeast to join the Port Huron moraine which comes up from the southeast. The angle is sharp and the forms of the moraines are quite simple, leaving no doubt as to contemporaneity.

In making the count of moraines, the central axis or line of least resistance in the valleys was followed in order to avoid the confusion of moraine knots. The oscillations of the ice front were there freest, and in the present case the line indicated from Cincinnati to Mackinac has no moraine complex. The series appears to be complete and without omission.

If we turn northeast at Toledo and pass down the axis of lake Erie and over into the lake Ontario basin, numbering Leverett's moraines as we go from the Toledo moraine as the eleventh, we shall find that the Albion moraine in western New York is the fifteenth. The interval remaining between the Cleveland and Hamburg moraines is so great as to suggest a possible omission of one member. But this is hardly likely. The Lockport moraine as the fourteenth corresponds to the Alcona moraine of Michigan, the fourteenth on the northward line. The fourteenth and fifteenth moraines undoubtedly pass along the south side of Georgian bay between lakes Huron and Ontario: and one or the other of these two probably records the ice barrier of lake Warren in its last stage.

The more important conclusions suggested by this paper were noted only very briefly. The irregularities in the moraine series are so simple that they are nearly all readily accounted for by the topographic features in the path of the moving ice-sheet. Such being the case. it becomes plain that if the irregular features of the land had been absent the moraine series would have been nearly if not perfectly regular. These characters point to the following conclusions: first. that the oscillations of the glacial recession were regular. periodic variations, superimposed upon the main recessional condition; and, second, that this main recession was itself nearly if not perfectly regular. It is possible, however, that the general recession had a slowly accelerating rate.

These conclusions obviously point to the cause of the oscillating recession as neither local nor terrestrial, but climatic and hence of astronomic origin. Thus the nature of the cause of the Ice Age is apparently disclosed by evidence drawn directly from observations on the drift. This subject, which in a different phase has been briefly considered by Woodworth in the last AM. GEOLOGIST (p. 167), will be discussed more fully at a future time.

The moraines here described were shown on a colored map. Other maps, illustrating portions of the themes of this and the preceding paper, have been given by Mr. Taylor in another very valuable paper, entitled "A Short History of the Great Lakes," in recent numbers of the Inland Educator (vol. II, pp. 101–103, 138–145, and 216–223, March, April, and May, 1896), published at Terre Haute, Indiana.

35. *The Operations of the Geological Survey of the State of New York.* JAMES HALL.

36. *The Eocene Stages of Georgia.* GILBERT D. HARRIS. The northern border of the Eocene of Georgia was indicated more correctly by White's map in 1849 than on maps of subsequent date; but the handbooks published by White, Stephenson, Henderson, and others, contain little reliable information on this subject. Lyell did some good work along the Savannah river, and properly referred the exposure at Shell Bluff to a horizon not far from the Claiborne. The mapping of the subdivisions of the Eocene in southwestern Georgia by Spencer, in 1891, must have been somewhat hasty, since it is now ascertained that nearly, if not quite, all the area he includes in his map as middle and upper Eocene is occupied by Vicksburg beds.

During the past summer the author has traced the Midway stage from the Chattahoochee river to Putnam, Marion county. The Lignitic stage seems not to be fossiliferous east of the Chattahoochee. The Lower Claiborne is represented by siliceous ledges seen at quarries two miles east of Ft. Gaines, where it is fossiliferous; in the central part of the state it is unfossiliferous and consists of whitish sands; on the Savannah it is marly and sometimes indurated, as at Shell Bluff.

The Vicksburg beds are enormously developed in southwestern Georgia, their northern limit passing four miles east of Ft. Gaines, five miles north of Cuthbert, one or two miles west of Andersonville, two miles south of Perry, past West Lake and Sandersville, and thence probably southeast to Screven county, though from Sandersville eastward Prof. Harris has not personally studied this stage. A remarkable outlier of Vicksburg rock is found twelve miles north of Fort Valley, at Rich Hill, Crawford county. The southern limits of this stage are still not well defined, especially in the southeastern part of the state.

37. *The Origin and Age of the Gypsum Deposits in Kansas.* G. P. GRIMSLEY. The gypsum beds of Kansas, mapped during the past summer for the University Geological Survey of the state, outcrop in a belt of varying width extending diagonally across the state in a northeast to southwest direction. They cover an area about 180 miles long, gradually widening toward the south; its width is 10 miles at the north, 20

miles in central Kansas, and 60 miles in southern Kansas. The deposit increases in thickness southward, from eight feet in northern Kansas, and from 14 feet in the central part, to 25 feet in southern Kansas, and farther south it is even thicker. The gypsum of northern Kansas is 1,250 feet above sea level; of the central portion, 1,300 feet; and of the southern part, 1,700 feet. The dip is in general south and a little east.

The gypsum occurs in three well marked areas, the northern Kansas or Blue Rapids area, the central or Gypsum City area, and the southern or Medicine Lodge area. The age of the northern deposit is Permian, referable to the Neosho division of Prosser. Its origin is due to the evaporation of an old gulf, which did not evaporate sufficiently for the deposition of salt.

In the central area there are two well marked layers of gypsum, the lower a gulf deposit, while the upper occurs in basins of eight to twenty acres each, having more the character of lake deposits. Here the gypsum rock belongs to the Marion division of the Permian of Prosser. This central area has also deposits of gypseous clay, of very considerable economic importance, which are clearly secondary and of recent formation, being due to the precipitation from gypseous springs and the wash from adjacent hillsides.

The southern or Medicine Lodge area of gypsum belongs to the Red beds, and was an evaporating gulf of shallow depth.

38. Geomorphic Notes on Norway. J. W. SPENCER. An account of the probable Tertiary and Quaternary epeirogenic movements and resulting land sculpture of Norway by subaërial erosion, based on the author's reconnoissances of that country during the past summer and in a former visit there, several years ago.

39. The Slopes of the Drowned Antillean Valleys. J. W. SPENCER. These slopes are shown to be no greater than those of the land valleys; and, indeed, their gradients are often found, when exactly determined, to be less than in the upward continuations of the same valleys on the land.

40. Notes on Kansan Drift in Pennsylvania. E. H. WILLIAMS. The border of the attenuated Kansan drift has now been examined from the Delaware river to Butler county, near the western line of the state. It is found that the rock erosion was nearly all accomplished before the farthest extension of the ice-sheet, and that the glacial motion was very slack toward the extreme border. There is a marked difference between the drift on the border east of Salamanca, N. Y., where the sharp turn is made, and west of that point. Evidently this angle indicates where two lobes from different directions and with different kinds of drift met and contended. The western lobe crossed to the east side of the Allegheny river down as far as Emlenton, a little above Parker's Landing, thus accounting for the high level gravels as far down as that point. These gravels are thought to have been quite generally brought in by glacial affluents from the west; and this may likewise be the origin of much material farther down the valley, which needs to be more fully studied.

The freshness of many of the pebbles in this oldest drift shows it to be of comparatively recent age, and not so enormously old as some have thought it to be. There are occasional pebbles which had evidently been deeply weathered and then were subjected to glaciation on one or two sides, so that the weathered parts are worn through. Since the glaciation the weathering has been slight, thus demonstrating that the presence of weathered pebbles in glacial deposits is not a certain evidence of great age. In this region the pebbles and cobbles had been rolled and weathered before the ice-sheet took them up. It is by no means improbable that the flowing ice incorporated in its current vast banks of sand and gravel in Canada, with pebbles already worn and weathered, and brought them across the Erie basin to the valley of the Ohio without much abrasion.

41. Preliminary Notes on the Columbia Deposits of the Susquehanna. H. B. Bashore. The sand and gravel terraces of this valley in the vicinity of Harrisburg, about 130 feet above the river, are shown to be due to river floods from the ice melting, not being indicative of subsidence of the valley.

42. Pre-Cambrian Baseleveling in the Northwestern States. C. W. Hall. The records of deep well borings to the Algonkian and Archean rocks show that they had been more or less fully baseleveled, with denudation to an approximately plane surface, cutting across the stratification and folds, before the deposition of the overlying Cambrian and later rock formations. Maps and sections have been drafted according to the records of the present subterranean contour of this Pre-Cambrian peneplain.

GEOLOGICAL PAPERS IN SECTION H (ANTHROPOLOGY).

Human Relics from the Drift of Ohio. E. W. Claypole. Specimens were exhibited which were regarded as proof of the presence of man in Ohio during the Ice Age, having been found near New London, Huron county, at depths ranging down to 22 feet from the surface, in gravel deposits that apparently can not have been disturbed since glacial times. This paper will be published in an early number of the American Geologist.

Fresh Geological Evidence of Glacial Man at Trenton, New Jersey. G. Frederick Wright. During last May, under the direction of Mr. Ernest Volk, a portion of the surface of the glacial sand and gravel terrace in the Delaware valley at Trenton, N. J., was dug over in the presence of Prof. Wright, for the sake of testing and demonstrating the succession of the stone implements described by Dr. C. C. Abbott in this gravel. The section explored began at the edge of the bluff on the Lalor farm, about one mile and a half from the center of Trenton, where it is about 50 feet above the river. A trench three feet deep and three or four feet wide was dug back from the edge about 30 feet, and all the material excavated was carefully examined. The upper foot of material was darkly colored with vegetable mould, and had evidently been disturbed. In this there were numerous implements and chips of flint and jasper, and an occasional piece of argillite; but in the lower

FIG. 1.

FIG. 2.

two feet of the excavation, which had evidently been undisturbed, no fragments of flint or jasper were found, but there were numerous chips and irregular fragments of argillite. Mr. Volk has in a similar manner excavated an area of an acre or more, with corresponding results, so that now there seems to be no further reason to question the facts reported by Dr. Abbott.

The evidence that this is glacial gravel, and that these argillite implements and chips were in the gravel at its original deposition, is thought to be incontrovertible. The terrace here is more than a mile wide, and is almost perfectly level; the excavations were made running back from the bluff which faces the river: the sand in which the argillite is found is stratified and compact: and there has been no chance for subsequent wash to cover so large an area with such a deposit, which is continuous with the whole terrace. Besides, ice-borne boulders, two or three feet in diameter, occur upon the surface at various places in the near vicinity. The sharply angular character of the fragments indicates that they were lost on the spot, and not rolled down by the flood. That they have not been carried down from the surface by burrowing animals, or through holes left by decaying taproots of trees, is clearly shown by the fact that only argillite is found in the lower two feet of the excavation.

Prof. F. W. PUTNAM supplemented this paper with a statement from Mr. VOLK, describing his subsequent work, and opened the box containing the specimens found by him, only argillite being noted below the surface soil or first foot of depth.

THE "AUGEN"-GNEISS AREA, PEGMATITE VEINS AND DIORITE DIKES AT BEDFORD, N. Y.*

By LEA McI. LUQUER, Ph.D., and HEINRICH RIES, Ph.D.

[Plates VIII and IX.]

CONTENTS.

EXTENT OF THE AREA.

Bedford lies in the northeastern part of Westchester county, about forty miles north of New York city and four miles southeast of Bedford station on the New York & Harlem R. R.

The prevailing rock in the vicinity is the gray Fordham gneiss, which is a fine-grained mixture of quartz, feldspar and biotite, showing distinct banding and normally rather quartz-

*Read by title at the Buffalo meeting of the American Association for the Advancement of Science, August 25, 1896.

ose.* In the northeastern part of Westchester Co. it may become rather schistose, due to the increased development of biotite.

Dolomitic limestone of later age (probably Trenton-Calciferous) is found in the larger valleys.

The "augen"-gneiss extends over an irregularly ovoid area, starting from a point about one and a half miles northeast of North Castle and extending six miles in a northeastly direction to Pound Ridge. Bedford village lies on the northwestern edge of the area, while the southeastern boundary runs approximately parallel to the Connecticut state line and about one mile distant from it.

The average width is 2½ miles, thus making an area of about 15 sq. miles (Plate IX, Fig. 6).

Within this area the prevailing strike is N. 30°-40° E. and the dip 35°-40° N. W.

THE "AUGEN"-GNEISS.

The normal phase of the rock is a fine-grained, gray, gneissic mixture, containing numerous "augen" of pinkish feldspar, thus giving the rock a distinctly porphyritic aspect. These feldspar "augen" usually form a large proportion of the rock mass. They vary in size, the average length being one inch, although some are three or four inches long and all show twinning after the Carlsbad law. These porphyritic crystals are in large part microcline or show "microclinic" structure as described later. On some outcrops where weathering has taken place the "augen" appear in bold relief (Plate VIII, Fig. 1).

In most cases the "augen" are elliptical in shape, with rounded or rectangular ends, and at times almost showing crystallographic boundaries. Again this shape is distinctly lenticular, as is well shown by a specimen from L. McDonald's quarry, where a portion of the large "auge" has been sheared off at the end of the lens (Plate IX, Fig. 5).

A constant feature is the parallelism which the "augen" show with the schistosity of the gneiss, but they are not always uniformly distributed through the rock, at times appearing in well marked bands of varying dimensions.

*F. J. H. Merrill. The Metamorphic Strata of Southeastern New York. Amer. Jour. Sci. (3), xxxix, 383. 1890.

On the northern edge of the area the rock is rather fine-grained and its structure approaches closely to the normal gray gneiss of the region (Nos. 0 and 4). The "augen"-gneiss is to be seen at the foot of Baylis' cliff (19), apparently underlying the ordinary gray gneiss and dipping 35°-40° to the northwest.

Along the northwestern edge of the area (Nos. 50 and 57) many garnets may be noticed and on the north and southwest edges rather dark gray hornblende-schists occur. In the field these schists appear very similar to a darker phase of the Fordham gneiss, but subsequent investigation may prove them to have the origin suggested by F. J. H. Merrill for similar hornblendic rocks found in Westchester Co., which he supposed to be altered diabase and diorite dikes.*

On the road from Bedford to Long Ridge and at Nos. 8, 11 and 13, the best examples of the "augen"-gneiss are to be obtained.

Near the southern edge of the area, by the Connecticut state line, the rock grades into a moderately fine-grained granitic type, which the microscope shows to be simply a more crushed phase of the "augen"-gneiss, while on the eastern edge of the area the Fordham gneiss again appears, but no passage from one to the other is seen.

There are marked evidences within this region of violent dynamic action, as shown by crumplings in the gneiss, pinching out of the "augen" and shearing phenomena. This is further substantiated by the microscopical examination of the specimens.

A remarkably good example of the wavy lamination of the gneiss can be seen in the Ferris cliff on the Banksville road, just south of the Bedford township line. The cliff lies east of the road and is about 30 ft. high, with a very steep slope leading up to the bottom. The local monoclinal folding of the dark gray gneiss is well shown in the face of the cliff, the laminations are very distinct and the gneiss is jointed to a marked degree. The feldspar and quartz are scattered through the gneiss in more or less granular veinlets. Near the upper portion of the cliff there appears quite a broad band

*Amer. Jour. Sci. (3). xxxix, 383, 1890.

of granitic rock and bands of the typical "augen"-gneiss also show in the face of the cliff.

It should be mentioned here that no field evidences of detrital origin have been observed.

Pegmatite Veins.

Within this area many more or less pure veins or masses of great size occur. Quarries have been worked in other localities, but the best of them seem to be included in the area just described. The larger deposits of commercial importance are marked on the map (Plate IX, Fig. 6) at *F*, *B* and *A*. The size of these pegmatite deposits can be inferred from the view of one of the quarry excavations on P. H. Kinkel's farm; see Plate VIII, Fig. 2. On A. Hobby's farm (*F*) a large, well exposed pegmatite vein is found, where the deep erosion of the Mianus river has laid bare large masses of very, pure quartz and feldspar. Just to the south of this exposure a fairly good granite occurs. P. H. Kinkel's quarry (*B*) is being worked at present principally for feldspar, which is ground in a mill on the place. The other small outcrops of feldspar and quartz are usually so mixed that they are not profitable to work. It will be noticed that the longer axes of the pegmatite masses follow the general strike of the "augen"-gneiss.

In these pegmatite deposits the quartz and feldspar occur in different conditions. At times they are found quite pure, in large, separate masses with sharp contacts; while at other times the quartz and feldspar occur intergrown as a true pegmatite, varying from an extremely coarse structure, with lenticular quartz, to a very fine graphic granite.

The quarries are cut through with veins of mica and veins of quartz, feldspar and mica, forming a coarse granitic rock. Black tourmaline, of the ordinary elongated type, is very common and seems to occur principally in the quartz near its contact with the feldspar. Its occurrence has not been noticed in the purely feldspathic portions of the pegmatite. In P. H. Kinkel's quarry, where an excavation has been made into a large mass of pure white quartz, the intergrowth of tourmaline with the latter is very marked. A close adjoining excavation shows chiefly feldspar, either pure or mixed with quartz as true pegmatite.

In these pegmatite areas the colors of the quartz and feldspar vary considerably. Rose, white and smoky quartz are found; while the feldspar varies from dark red to almost white, which loss of color seems to be due to kaolinization, especially near the surface. "Perthitic" intergrowths of feldspar are noticed in P. H. Kinkel's quarry.

The two following analyses of feldspar from P. H. Kinkel's quarry show it to be high in potash, with practically an absence of lime. The feldspar seems to be chiefly orthoclase, although many evidences are shown microscopically of microclinic structure.

	I	II
SiO_2	64.97	65.85
Al_2O_3	20.85	19.32
Fe_2O_3	tr.	.24
K_2O / Na_2O	13.72	14.10
H_2O (by loss)	.46	
CaO		.56
MgO		.08
	100.00	100.15

No. I. Furnished by P. H. Kinkel.
No. II. "Chemistry of Pottery" p. 38. C. Langenbech, *Anal.*

Unfortunately no contacts of the quartz and feldspar with the porphyritic or "augen"-gneiss were obtained, as the excavation has always stopped when the minerals became too mixed to be of commercial value. So far as the surface outcrops go, the change to the surrounding rock seems to be gradual and there is no evidence of an irruptive contact between the pegmatite and the "augen"-gneiss.

In the southeastern portion of L. McDonald's quarry (*A*) there occurs a steep wall of biotite-hornblende schist, somewhat decomposed and forming an abrupt bounding wall to the pegmatite. The dip is very steep and the strike S. 30° W.

There are very few good contacts with the schist to be observed, as the quarrying has not been pushed that far on account of the impurities encountered. At one place, however, near the mouth of the excavation a very sharp contact can be seen. A section of this contact showed the pegmatite to consist of quartz, plagioclase and orthoclase, the latter containing plentiful hematite inclusions and, near the contact, enclosing small rounded grains of quartz. The contact under the mi-

croscope did not appear to be very sharp, but was marked by a line of biotite shreds and a finer grained structure in the pegmatite.

The dark schist showed an excess of biotite and a few hornblende shreds, with a good deal of slightly decomposed orthoclase and subordinate plagioclase and quartz. The orthoclase contained a few hematite inclusions, while small crystals of apatite and titanite were not uncommon. Evidences of dynamic action were not shown by any of the minerals in the section examined.

Quite near this contact there were observed several fine pegmatite stringers running into the schist. A microscopic examination showed no strains in either the minerals of the stringers or the schist. The mineralogical composition at these points was practically the same as at the sharp contact just mentioned. The outline of the stringers was well marked even under the microscope, a very similar appearance being shown by a specimen in pl. I, fig. 3 of Lehmann's work.*

The same section showed apatite grains yielding a distinct negative uniaxial cross.

The absence of any marked evidences of dynamic action (such as crushing, wavy extinction or lines of inclusions) in the quarry specimens examined is to be commented on as being in marked contrast to the conditions occurring throughout the rest of the "augen"-gneiss area, as shown later.

The occurrence of schist as a wall-rock is local and has not been noticed in any of the other quarries.

Diorite Dikes.

These are found at Nos. 14 and 27 in the area.

Dike, No. 14, appears on the cross-road between the Middle Patent church and the Banksville road, two miles due north of Banksville.

Dike No. 27, occurs about half way down the southeastern slope of a steep hill on the Long Ridge road about 1½ miles northwest of Long Ridge.

In both instances the outcrops are of limited extent.

Dike No. 14. The rock is essentially a moderately fine-grained diorite and appears on both sides of the road. The general color is greenish gray, and its hornblende crystals

*Die Entstehung der Altkrystallinischen Schiefer.

show quite distinctly on the weathered surface. At times the plagioclase almost disappears, leaving a schistose aggregate of hornblende and mica. A more or less decomposed phase of the gneiss was noticed which consisted of abundant plagioclase and mica. Very near the dike a good specimen of the "augen"-gneiss was obtained and a vein of white quartz outcrops just northwest of the road within a hundred feet of the dike.

Dike No. 27. The rock is essentially an aggregate of hornblende crystals with a little mica and varies considerably in texture. The color is a dark greenish black, and portions near the contacts are considerably decomposed. Garnets are extensively developed in the adjoining gneiss. The "augen"-gneiss appears on the same slope and quite near the dike, which has probably branched, as a small isolated outcrop occurs by the road side at the top of the hill. The large pegmatite vein on A. Hobby's farm (*F*) is about three-eighths of a mile southwest of the dike.

Petrography of the Area.

"*Augen*"-*Gneiss*. This consists essentially of orthoclase, quartz and biotite. The orthoclase is for the most part present in the shape of "*augen*" of varying size, with lenticular outline. Carlsbad twinning is the rule and microcline sometimes replaces the orthoclase either wholly or in part. "Microclinic" structure may however be developed in the orthoclase as the result of dynamic action, as it often has a rather inconstant appearance.* Alteration to kaolin is noticed but not to any great extent. A few quartz inclusions occur in the "augen" and wavy extinction is very marked as the result of dynamic action. A section of an "auge" parallel to the twinning plane (No. 11) showed, with reference to the basal cleavage, the characteristic small extinction angle (5°-7°) of orthoclase. This section also showed a few small Carlsbad twins, of the same species, lying parallel to the cleavage planes. These inclusions were usually surrounded

*A. Harker, *Petrology for Students*, p. 279.
J. W. Judd states that "the great mechanical strains, to which rock-forming orthoclases have in some cases been subjected, has frequently caused them to assume the external angles, the internal structure and optical properties characteristic of microcline." *Geol. Mag.* [3], VI, 243, 1889.

by an irregular, narrow border of secondary quartz. Another section of an "auge" (No. 15), cut in a similar direction, showed the same small extinction angle; and evident granophyre structure was noticed in some of the bounding feldspar grains. This "auge" was bent, showed the usual wavy extinction and was surrounded by a crushed rim of feldspar and quartz, the former being in excess. Wavy extinction was also noticed in some of the quartz grains.

In one case (No. 13) a section of an "auge," perpendicular to the twinning plane, showed the crystal to be much bent and cracked, with the undulatory extinction very marked (Fig. 3) and the usual crushed rim of mineral fragments.

FIG. 3. Section of an orthoclase "auge" (Carlsbad twin), showing wavy extinction and bending, surrounded by crushed rim of mineral fragments. As seen with crossed nicols (No. 13).

The quartz individuals do not appear as "augen," for in the metamorphism that the rock has undergone they seem to have been more broken or crushed. In a few cases elongated individuals, parallel to the general schistosity, have been seen. It is also to be noted that the wavy extinction is less marked in the quartz than in the feldspar individuals, which seem to have adjusted themselves to the strain. In most cases the absence of inclusions in the "augen" is very marked and stands in strong contrast to the conditions which exist in the gneissic rocks farther south in Westchester Co.* The quartz sometimes extends into the "augen," forming corrosion bays (No. 6).

*H. Ries. On a Granite-diorite from Harrison. Westchester Co., N. Y. Trans. N. Y. Acad. Sci., xv.

The shearing force which has produced the "augen" has at times pulled off pieces from the ends of the larger lenses, thus giving rise to a train of feldspar lenticles extending in a direction parallel to the diameter of the lens, as shown in a section from No. 9. A good example of the formation of one of these smaller lens is shown in Plate IX, Fig. 5.

The possibility of the "augen" being true phenocrysts or segregations seems to be barred out by the absence of noticeable inclusions or secondary enlargements and by the presence of marked wavy extinction. Furthermore the "augen" are in nearly every case surrounded by crushed rims.

The fine-grained *groundmass* of the rock is composed of feldspar, quartz, biotite, muscovite, and in lesser amounts apatite, zircon, garnet, hornblende and magnetite.

Feldspar is principally orthoclase, although plagioclase and microcline are present. It is usually granular and shows, at times in a very marked manner, its derivation from larger individuals by crushing. Wavy extinction may be seen in most of the larger fragments. At times the microcline is evidently paramorphic after orthoclase. Evidence of decomposition is seen in all three of the varieties of feldspar, but has not proceeded far.

Quartz, in addition to the characteristics mentioned before, shows abundant inclusions, the commonest of which are exceedingly small and dust-like. They are sometimes arranged in strings normal to the schistosity.

Biotite, having the usual appearance and of a brownish color, occurs plentifully distributed through the rock, the shreds in general lying parallel to the schistosity.

Muscovite is seen in lesser quantity.

Apatite and *zircon*, of the usual habit, occur plentifully as inclusions and some of the zircons show distinct pleochroism.

Garnets, with more or less centrally aggregated inclusions, characterize certain phases of the gneiss.

Hornblende shreds were seen in a few sections.

Magnetite grains occur sparingly.

SCHISTS.

Schists from Nos. 23, 40 and 55, previously mentioned as being possibly metamorphic diabase dikes, appear in sections to vary somewhat in mineralogical composition and to consist

of a granular mixture of fresh hornblende, feldspar, biotite and quartz. The feldspar is mostly plagioclase, although microcline and orthoclase are also present. A few small apatites were noticed, and also granular titanite, sometimes enclosing cores of magnetite, evidently titaniferous. Chlorite is present, but rare. A few of the plagioclase grains show dynamic action, and the dark ferro-magnesian constituents are at times much corroded.

DIORITE DIKES.

Dike at 14. This intrusive consists normally of a moderately fine-grained diorite with hornblende, much plagioclase and some biotite, having a holocrystalline structure. This structure may become schistose at times, when a marked increase in hornblende or even biotite is noticed. The rock also assumes a fine-grained phase at points along the edge of the dike (14f).

Plagioclase, the important feldspar, is often slightly kaolinized and rarely shows any wavy extinction. A prominent feature is the universal presence of inclusions, which are sometimes so minute as to appear as dust-like masses and at other times consist of small dots and rods, often arranged in rows of a dozen or more. These various inclusions are almost identical with those described by the late Prof. Williams in the feldspar of norites of the Cortlandt series near Peekskill, N. Y.* Rutile needles and hexagonal plates of mica are also included. One section (14f) showed small needles of an undetermined mineral, with inclined extinction, occurring in the plagioclase.†

Some of the plagioclase seems to have formed before the hornblende (14d), as shown by the inclusions of the former in the latter. This reversion of the usual order of crystallization has also been noted by J. F. Kemp in the Cortlandt rocks at Rosetown, N. Y.‡

Orthoclase is rarely present.

Hornblende is very abundant and is usually in the form of rather broad plates with corroded outline. The alteration is

*Amer. Jour. Sci. (3), XXXI, 26.

†These may be pyroxene microlites similar to those noted by J. F. Kemp as occurring in the labradorite of the Adirondack anorthosites. Bull. Geol. Soc. Amer., v, 216.

‡Amer. Jour. Sci. (3), XXXVI, 251, 1888.

accompanied by bleaching and the separation of magnetite, which forms abundant included grains irregularly distributed.

Biotite is rarely present, although somewhat abundant in No. 14g, where it showed intergrowths with hornblende and also a few inclusions of the latter mineral, proving that the hornblende began to form first but had not ceased before the commencement of the biotite crystallization.

Rutile is common in the form of slender needles in the feldspar.

Apatite, of the usual habit, occurs as inclusions in the feldspar, and a few prismatic crystals of *tourmaline* were also found.

Magnetite is sparingly present, usually as inclusions in the hornblende.

Pyroxene, in small granular masses, was seen in one section (14g).

Titanite, *zircon* and *pyrite* are rare, as is also interstitial *quartz*.

Dike at 27. This intrusive varies considerably in texture from coarse to fine and also in mineralogical composition. The sections, from the more central portions of the outcrop, show that the dike consists essentially of a hornblendic rock (amphibolite) composed of an aggregate of interlaced hornblende and biotite individuals, both containing plentiful inclusions of magnetite. Towards the edges of the dike the rock appears as a mixture of irregular plates and broken fragments of hornblende, intimately mixed with granular pyroxene and titanite with subordinate biotite. The hornblende, in this phase, contains inclusions of titanite and granular pyroxene, which latter show no connection, in their optical orientation, either with respect to themselves or their host. Augite has also been noticed by J. F. Kemp, both as inclusions in, and at the same time surrounding, hornblende crystals, evidently formed from the latter mineral by resorption.*

Hornblende occurs as the prevailing mineral in lath-shaped individuals, broken fragments or shreds. The color is green and the mineral exhibits its characteristic absorption and small extinction angle. No evidences of uralitization are seen, and the before mentioned inclusions are common.

*Amer. Jour. Sci. (3), xxxvi, 251, 1883.

Biotite, of brown color, strong absorption, and characteristic form occurs in varying amounts.

Feldspar is found in grains, at times showing the polysynthetic twinning of plagioclase. It shows only slight evidences of strain, and occurs as a subordinate mineral, except at 27a and 27g along the edges of the dike, where it is the prominent constituent and gives the rock the more normal diorite appearance. The axial angle at times is very small, giving almost the uniaxial cross of quartz. Decomposition is not marked as a rule.

Pyroxene is present as an accessory mineral in light greenish grains, with its usual large extinction angle, bright interference colors and absence of pleochroism.

Titanite is unusually developed in this dike. One very large crystal was noticed in 27c (Fig. 4). The crystals, of the common wedge-shape habit, are nearly colorless and exhibit marked pleochroism. They compare very favorably in size with the large yellowish red titanites, seen in the syenite of the Plauenschen Grund, Saxony.

In some cases the titanite appears with cores of titaniferous magnetite.

FIG. 4. Large titanite crystal (in the center of the section) and granular mixture of hornblende (h), feldspar (f), biotite (b), pyroxene (p) and apatite (a). Dike No. 27.

Apatite is seen in large grains in the basic portions of the rock, and in slender hexagonal prisms in the feldspar, for which the larger grains might easily be mistaken, except for the more marked relief and the uniaxial interference figure.

Zircon of the usual type is found in very subordinate amounts.

Quartz is noticeably absent, only appearing in small grains in section 27c.

Rutile is practicably absent from this dike, the titaniferous mineral being titanite, which is in marked contrast to the dike at 14 in which rutile is so abundant.

The *iron ores*, magnetite and titaniferous magnetite, are found in small grains in varying amounts. At times the magnetite is plentifully developed in the hornblende and biotite. Pyrite is also found.

Some of the sections of dike 27 bear a resemblance to the Crugers diorite, in which, however, the plagioclase is better developed and the hornblende more pleochroic, containing also more magnetite inclusions.

A section of the gneiss (27) near this dike, showed abundant development of garnet as the result of contact metamorphism; and a few rather short rutile needles were noticed in quartz grains in this section.

Origin of the "Augen"-Gneiss.

A discussion of the probable origin of the "augen"-gneiss, and the metamorphism to which it has been subjected, would hardly be complete without reference to the investigations and conclusions of other writers, dealing with rocks of similar appearance.

The question of the origin of the gneissic rocks is in general more or less obscure. The Fordham gneiss is at present being studied by F. J. H. Merrill. The gneisses of the eastern Adirondack region give little decisive evidence of their origin, while those in the township of Gouverneur on the west side, investigated by C. H. Smyth, Jr., appear to be derived from granitic rocks; a fact which, as suggested by J. F. Kemp, lends support to the theory of the granitic origin of gneisses in other regions. The Gouverneur gneiss differs from both the Fordham and "augen"-gneiss on account of the microperthite contained in it. The rock however resembles the "augen"-gneiss slightly in that it sometimes assumes a porphyritic phase.*

The so-called "augen" structure in rocks has been noted from a number of localities, but in most cases, especially in

*C. H. Smith, Jr., Trans. N. Y. Acad. Sci., XII, June, 1893.

this country, the origin seems to have been different from that of the Bedford gneiss.

W. H. Hobbs.* in his paper on the Schists of the Southern Berkshires, Mass., states that the large porphyritic feldspars are often filled with secondary granophyre and frequently show secondary enlargement. These porphyritic feldspars are more or less oval in shape and consist of an acid plagioclase. The "augen" may show no marked evidence of strain, except polysynthetic twinning about cracks, and the granophyre structure seems to give evidence of being secondary and not therefore proving the igneous origin of the rock. Secondary enlargement of the feldspars is very common and is regarded as recrystallization of the detrital grains of the clastic rock, produced by static metamorphism (pressure, aided by heat and mineralizers).

The importance of the enlargement of mineral fragments in clastic rocks as a factor in their alteration by metamorphism has been emphasized by Irving and VanHise in their papers on the lake Superior region.

C. L. Whittle,† in his work on the "Dynamic and Metamorphic Phenomena in a Metamorphosed Conglomerate in the Green Mountains," states that the larger porphyritic crystals of albite (¼ in. across and simple crystals or once twinned) in the chlorite schists at East Clarendon. Vt., were formed as secondary minerals by chemical solution and contain plentiful inclusions. A fissuring or faulting of the large albites was caused by a second period of mountain building forces.

In N. H. Winchell's‡ paper, on the Origin of the Archæan Greenstones, mention is made of the fact, reported by G. H. Williams, that the feldspars have apparently withstood the pressure better than the quartz. The theory advanced by him is that the feldspars were produced by the chemical action incident to the later dynamic forces and he calls attention to the fact that the feldspar is fresh in the most crushed portions of the rock.

J. E. Wolff,§ in his paper on the Metamorphism of Clastic Feldspar in Conglomerate Schist, describes porphyritic albite

*Bull. Geol. Soc. Amer., IV, 167.
†Bull. Geol. Soc. Amer., IV, 118.
‡Geol. & Nat. Hist. Surv. Minn., Pt. II, 23d Ann. Rept.
§Bull. Mus. Comp. Zool., XVI, No. 10.

grains of variable size which are often twinned in two simple halves. They are clear and fresh and contain inclusions. The appearance of the clastic grains which have been enlarged is also described and the porphyritic development of the feldspar seems to be due to secondary enlargement or almost complete recrystallization.

Wolff* also mentions that the Stamford gneiss, whose origin is still doubtful, contains large porphyritic twins of microcline. It is evident that in this rock the development of the mica, quartz and feldspar, parallel to the planes of breaking and sliding, has had a great deal to do with the parallel structure; hence it might have been an eruptive granite modified by metamorphism, but the field relations point to a detrital origin. An "augen"-gneiss, occurring in Hoosac mountain, and containing rounded feldspar crystals is also mentioned by Wolff. In this instance the rocks have been crushed by great pressure, accompanied by shearing action, which has formed new feldspar, mica and quartz.

As further instances of similar structure in rocks, but having an origin more like that of the Bedford "augen"-gneiss, may be mentioned the occurrences described by Lehmann in his great work on "Die Entshehung der Altkrystallinischen Schiefer," in which there are given numerous examples of the production of "augen" by shearing forces, as illustrated in pl. X, fig. 5; XI, fig. 5, and XII, figs. 4 and 3, the latter especially resembling the "auge" figured from McDonald's quarry (see Plate IX, Fig. 5 of this work). Lehmann states (p.249) that the feldspars possess a special interest because of the excellent manner in which they show the result of pressure in bending, splitting, etc. He considers, however, that their surroundings must have been very firm, as only under such conditions would the slightly pliable feldspars stand bending and stretching, and he furthermore thinks that the cracks which they show, and which may or may not be filled with foreign material, preclude the possibility of the feldspar having been in a fused condition.

C. Callaway† has described a mica-gneiss, from the Malvern hills, which has resulted from a granite by crushing. The

*Mon. XXIII, U. S. Geol. Surv.
†Quart. Jour. Geol. Soc., XLIII, 525, 1887.

feldspar, as a result of dynamic action, forms "augen," which are often sheathed by mica. Quartz may also surround the feldspar or form wedge-shaped masses.

A further occurrence of feldspar (orthoclase) "augen," mostly Carlsbad twins, has been noted by E. Dathe* from the mica-gneiss of the Eulen Gebirge.

In New York state J. F. Kemp has observed a complete transition, due to crushing, from the unchanged Adirondack anorthosite to the gneissic form of the same rock, showing the abundant development of feldspar "augen," which are evidently the uncrushed portions."†

J. G. Goodchild, in his paper on "Augen Structure in Relation to the Origin of the Eruptive Rocks and Gneiss," states that it results from either, 1st, the "augen" being the unsheared portions, or, 2d, the "augen," consisting of crystalline minerals bright and unfractured, being developed subsequent to the shearing. A release of pressure along the shearing planes in a rock which is in a state of potential fusion would cause fusion and give a chance for the crystals to segregate.‡

It is evident that the present porphyritic structure of the Bedford rock is not the original one; and, considering carefully the facts mentioned in the previous pages, there is no doubt of active dynamic metamorphism having been the cause of its alteration.

As to the previous condition of the rock it may have been igneous or detrital. The latter theory, however, seems to be precluded by the fact that none of the usual evidences found in metamorphic rocks, indicative of their clastic origin, are found in the Bedford "augen"-gneiss. Such evidences are the secondary enlargement of the quartz or feldspar accompanied, especially in the case of the feldspar, by the presence of abundant inclusions; and the appearance of the waterworn boundary of the cores, unless recrystallization has been complete.

The tendency to regard it as a metamorphosed igneous rock is therefore natural; and if this is so, it must have been a rock low in lime, magnesia and iron and high in alka-

*Zeitschr. d. d. Geol. Ges., xxxv, 219.
†Lect. Notes on Rocks, S. of Mines Quart., XVII, 158, 1896.
‡Geol. Mag. (4), I, 355, 1894.

lies, therefore containing much feldspar, such as a granite or aplite. The result of the metamorphic action seems to have been the production of a gneissic structure caused by pressure, together with a granulation of the minerals resulting from shearing, the unsheared portions of the rock remaining as "augen." The evidences of this metamorphic action appear as strains, bending, breaking and wavy extinction in the larger individuals, and in the granulation of the other constituents. This idea of the origin of "augen" structure based entirely on crushing and shearing, seems to be also held by Kemp, Callaway, Lehmann and others as already noted. There is nothing to prove that the strains in the "augen" occurred subsequent to the forces which produced the crushed groundmass.

Concerning the porphyritic aspect assumed exclusively by the feldspar, two theories suggest themselves: 1st, involving the idea of segregation advanced by N. H. Winchell and J. G. Goodchild, both already mentioned; and, 2d, that the quartz being more brittle than the feldspar would crack more easily, although it might be urged that the feldspar would give way first on the account of its cleavage.* The fusion point of quartz being far above that of orthoclase the latter might become softened by the heat, produced by dynamic action, while the former was still hard and brittle. The softened orthoclase would then accommodate itself to the strain of shearing by being drawn out.

While this latter theory is at variance with that put forth by Lehmann, for the formation of feldspar "augen" in the Saxon granulites, it does not seem quite manifest how a piece of feldspar could be pulled out into a lenticular shape without being first softened (but not necessarily fused). Furthermore it would not seem that the presence of cracks is a positive proof against a former softened condition of the feldspar

*In this connection it is well to remember that the theoretically perfect cleavage of feldspar is often only made apparent, by the rending effect of grinding, in very thin sections.

for these cracks and fissures might be produced by strains within the mass incident to shrinkage on cooling.*

The notable absence of inclusions in the feldspar "augen" would seem to exclude the idea of their formation by segregation. The presence of granophyric structure, which has been noted in a few cases in the Bedford "augen"-gneiss, does not throw much light on the genesis of the rock, as granophyric structure can no longer be looked upon as necessarily denoting igneous origin. (See Hobbs' paper previously quoted.) The extreme to which the dynamic action has been carried locally is shown by the granitic phase of the rock on the southeastern border of the area, where the gneiss has been so crushed that none of the "augen" are left.

The origin of the Bedford pegmatite veins is equally interesting. Pegmatite veins are not at all unusual in other localities, and are probably much more plentiful than the records show. There are many of these occurrences in Westchester county, and along the Connecticut shore of Long Island sound. Pegmatite veins of great size are mentioned by J. F. Kemp† as occurring in gneiss near the contacts with gabbro and anorthosite, in the Adirondack region. Granitic and pegmatitic veins are also noted by Cross as cutting peculiar schists at Salida, Col.‡ Those which have been described by L. G. Westgate§ from the New Jersey highlands, are apparently considered by him to be igneous.

Other marked occurrences are at Portland and Branchville, Conn.; Dillsboro, N. C.;‖ Brandywine Summit, Pa.;¶ and Blandford, Mass.**

A valuable contribution on the origin of pegmatites has just been published by Mr. G. H. Williams in his paper on

*Regarding the amount of shrinkage in cooling, J. Beckenkamp (Zeitschr. fur Kryst. u. Min. V, 461, 1881,) gives the coefficient of cubical expansion for orthoclase as .00129 for 60°C. According to this, and assuming the orthoclase to have been heated to near its fusion point, viz. about 1200°C., it would shrink about 2.5 per cent. in cooling. This would probably be sufficient to cause strains with resultant cracks. Under conditions of great pressure the temperature might far exceed 1200°C before plasticity could occur.

†Bull. N. Y. State Mus., vol. III, Nov. 14th, 1893.

‡Proc. Col. Sci. Soc., Jan., 1893.

§Ann. Rep. N. J. Geol. Surv., 1895.

‖J. A. Holmes, Trans. Amer. Inst Min. Eng. vol. XXVI.

¶Rept. of Prog., Pa. Geol. Surv., 1885.

**W. O. Crosby, Technol. Quart., 1890.

"General Relations of the Granitic Rocks in the Middle Atlantic Piedmont Plateau."*

In this paper Prof. Williams mentions the theories advanced by different writers and comments on the probable correctness of the aqueo-igneous origin of pegmatites, as advocated by Lehmann, Brögger and others. Regarding the source of the material, the lateral secretion process seems to be the one accepted by most writers for the origin of the material.

In Maryland, where the pegmatites are especially abundant, Prof. Williams considers that there are examples of both segregational and intrusive ones. The former are generally lens-shaped like many quartz veins, which have evidently formed in the same manner, and they also show a banding parallel to their walls. In the intrusive pegmatites there is no banding, the boundaries are sharp and the character of the dike does not seem to bear any relation to the chemical composition of the wall rock. Their structure is usually coarse, but fine-grained phases may occur. Their igneous origin is shown by the manner in which they branch and cut across the strike, and include fragments of the wall rock. The liquidity of the rock, as well as the pressure under which it was erupted, is inferred from the minute fissures which it sometimes fills. Intrusive pegmatite dikes may be concordant with the foliation of the gneiss, on account of their having followed the line of least resistance.

In the case of the Bedford pegmatites it seems hard to conceive that such coarsely granular masses of quartz, mica and feldspar could be formed from igneous fusion, or that large and comparatively pure masses of quartz, many feet in width, should be the result of igneous processes. A hydro-thermal origin seems more likely, and the occurrence of abundant tourmaline also indicates the presence of mineralizers.

A similar theory regarding the origin of the larger veins of pegmatite in metamorphic regions has been suggested by J. F. Kemp,† who says: "It seems improbable that true igneous fusion could have afforded such coarsely crystalline aggregates and so we are forced to assume such an abundance of steam and other vapors as to almost if not quite imply solution."

*15th Ann. Rept. Director U. S. Geol. Surv., p. 657.
†Lecture Notes on Rocks, S. of Mines Quart., XVII, No. 2, 1896.

The notable absence of small crystals of both quartz and feldspar in the Bedford pegmatite would favor a chemical rather than an igneous origin. The occurrence of large orthoclase crystals at South Lyme, Conn., would also indicate a chemical origin for the pegmatite veins of that locality, and it is not unreasonable to assume a similar origin at the two places. One of these large orthoclase crystals from South Lyme, collected and described by W. D. Matthew, measured 5½ by 4½ inches.*

It will be noticed from the map that the pegmatite veins generally occur parallel to the strike of the "augen"-gneiss, which would be natural if we assume a vein formation, the solutions having followed pre-existing fissures or lines of weakness. They also seem to have permeated the wall-rock somewhat, thereby causing a gradual transition from the vein material proper to the "augen"-gneiss. In only one instance was a sharp contact noticed, see p. 243 giving account of L. McDonald's quarry.

The pegmatite veins are evidently of later origin than the "augen"-gneiss, for sections of both the granitic and graphic-granite type show the minerals to be in their normal condition without any signs of dynamic action, which would appear if they had been subjected to the same metamorphism as the surrounding area.

It seems improbable that the theory advanced by Goodchild for the formation of pegmatite veins, namely the release of pressure and segregation from a fused mass, could apply to the Bedford pegmatites, which show exceedingly coarse structure. Goodchild's theory, however, accounts very well for the gradual passage of a pegmatite into the surrounding rock.

That the diorite dikes are intrusives, subsequent to the metamorphism of the "augen"-gneiss, seems to be proved by the fact that the component minerals do not show any marked dynamic action, and no proof of the hornblende being paramorphic after augite has been discovered.

Mineralogical Laboratory of Columbia University, July, 1896.

*Contributions from the Min. Dept., Columbia University, vol. VI, No. 2.

APPENDIX.

THE MINERALS OF THE PEGMATITE VEINS AT BEDFORD, N. Y.

By Lea McI. Luquer, Ph. D.

Autunite is found in one small vein in P. A. Kinkel's quarry. It occurs in little, bright, greenish-yellow flakes, between the leaves of mica and the more or less open cleavage of the feldspar. One fair sized tabular crystal was found, but unfortunately was too much broken to permit of measurements being made. The autunite gave satisfactory tests for Ur. and P.

Feldspar occurs in quite large rather pure masses, or mixed with quartz. The feldspar in the quarries is principally orthoclase, although at times it is largely replaced by microcline. The color and chemical composition have been already given in the preceding article on "Augen"-gneiss.

No crystals, except the rather incomplete "Augen" of the gneiss, have been discovered in this locality.

Garnet, of the common tetragonal trisoctahedron form (211), 2-2, is found more or less plentifully, especially in the quarries belonging to L. McDonald and M. Bureusch. The crystals occur in little veins in the feldspar or sometimes between large plates of mica, when they have a tabular habit, being flattened parallel to two of the trisoctahedron faces. The garnets are usually rather small in size and vary in color from a dark, reddish-brown to a pinkish-red. At times they are a good deal decomposed. The dodecahedron form (110), *i*, was noticed on one specimen from Kelt's quarry.

Menaccanite, in the tabular form characteristic of the variety washingtonite, occurs sparingly in the large quartz vein in P. H. Kinkel's quarry, associated with tourmaline and quartz.

Mica is found in abundance, principally the species muscovite and biotite; and occurs in more or less distinct veins or coarsely mixed with feldspar and quartz.

Muscovite appears in tabular crystals or foliæ of varying size (sometimes four inches broad), and the smaller crystals show the hexagonal type of form. The color varies from a pale browish-gray to a light greenish-brown. The axial angle is large, as shown by the polariscope.

Biotite appears in tabular hexagonal crystals or in a peculiar blade-like habit, with very marked elongation in one direction. The color is dark greenish-brown or black. The uniaxial character can be seen with the polariscope.

In some places little glistening scales of a silvery mica are found on the feldspar.

Quartz, usually massive, is a very common mineral in this locality and occurs in large masses or mixed with feldspar as pegmatite. The color varies from white through shades of gray to a very dark smoke color. Rose quartz is often met with, some of a very deep, rich color being found at A. Hobby's quarry. A few rather fine smoky quartz crystals have been found at P. H. Kinkel's quarry. The quartz shows positive evidence of having been formed subsequent to the mica, as in some cases beautiful step-like casts of the mica plates can be seen in the quartz.

Tourmaline is very plentiful, especially at P. H. Kinkel's quarry. It is black in color, with an elongated prismatic habit, the prism faces showing marked striations. The following common forms have been observed:

The trigonal prism (10$\bar{1}$0), *I*; the prism of the second order (11$\bar{2}$0), *i*–2; the unit rhombohedron (10$\bar{1}$1), *R*; and in one case the *2* rhombohedron (02$\bar{2}$1),—2.

Crystals of large size are found at A. Hobby's quarry, but no doubly terminated crystals have as yet been collected. When tested with the blowpipe the tourmaline gave the boron flame, with the boracic acid flux, and fused rather easily with intumescence to a black glass.

*Uraninite.** Two quite large specimens of this mineral were found in a dump heap in P. H. Kinkel's quarry, very near where the autunite occurs. The mineral is black, with pitch-like lustre and the characteristic conchoidal fracture of uraninite. The test for Ur. was obtained with the blowpipe.

Uranotile or uranophane occurs as a yellow powder or crust on the uraninite.

A careful but unsuccessful search was made for the rare minerals monazite and xenotime, which have been found in the pegmatite on Manhattan island. Monazite has also been

*Uraninite has also been noted in a feldspar quarry at Middleton, Conn., and a pegmatite vein at Branchville, Conn.

FIG. 5.

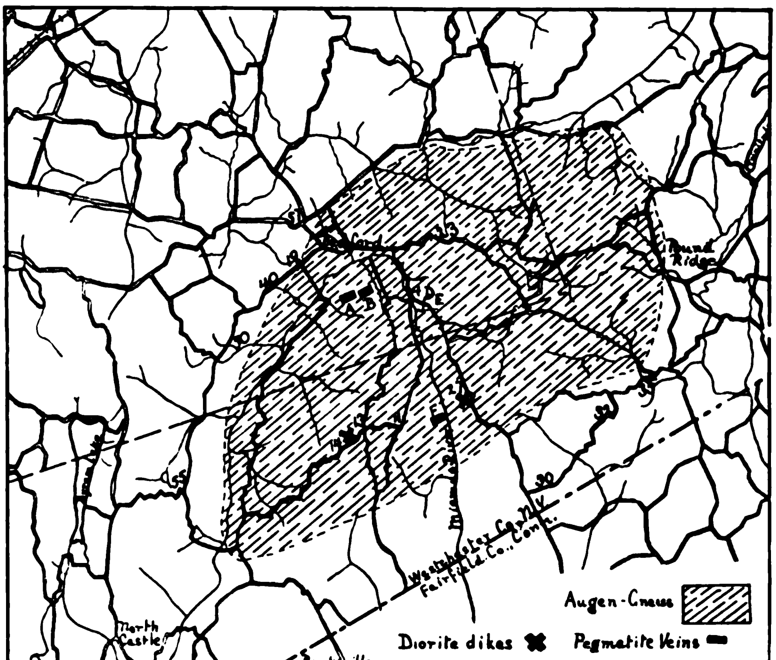
Augen-Gneuss
Diorite dikes
Pegmatite Veins
Round Ridge
North Castle
Bankville
Westchester Co., N.Y.
Fairfield Co., Conn.

FIG. 6.

described by W. D. Matthew from a pegmatite vein at South Lyme, Conn.*

EXPLANATION OF PLATES.

PLATE VIII.

FIG. 1. Weathered surface of gneiss showing the "augen."

FIG. 2. View of a quarry excavation in the great pegmatite vein on farm of P. H. Kinkel (marked B on map).

PLATE IX.

FIG. 5. Lenticular feldspar "auge," showing at the left end smaller portion which has been sheared off.

FIG. 6. Map of "augen"-gneiss area.

A NEW AND IMPORTANT SOURCE OF PHOSPHATE ROCK IN TENNESSEE.

By JAMES M. SAFFORD, State Geologist.

Much interest has been created recently in middle Tennessee by the discovery of a new source of available phosphate rock in large quantities. This new source is one wholly different from that yielding the now well known rock of Swan creek in Lewis and Hickman counties, Tennessee. They are of very different geological horizons. The rock of Swan creek is Devonian; the one to be described is Trenton. That is a true rock itself; this is a residuum after the leaching of a rock. The rock is found in workable bodies over a wide area, including, it may be, fifteen or twenty square miles of surface. In small quantities, in isolated pieces or blocks, washed out of the soil, it is found in all the counties of middle Tennessee, showing outcrops of the geological horizon to which it belongs, as, for example, in Davidson county and within the very corporate limits of Nashville.

The centre of the present workings and interest is in the town of Mount Pleasant, in the southern part of Maury county. Here the phosphate is found, after stripping off the soil, in banks from three to eight feet in vertical thickness. Half a dozen companies are busily engaged in getting it out. From 200 to 300 hands are at work, and where a few weeks ago everything was quiet, now all is bustle and excitement.

The rock is light yellowish or grayish, of an open, spongy structure, and occurs in layers or plates of various thickness from an inch to six inches or more. The layers are found

*School of Mines Quarterly, vol. XVI, p. 232.

regularly or irregularly piled together in great stratified masses like walls of masonry, here intact and there more or less broken down. Sometimes earthy matter is interlaminated. The material is easily quarried, picked out in blocks without blasting. All the stripping required is the removal of the soil. The rock has much the appearance of chert, such as is often liberated from cherty limestones by the leaching away of the calcareous part. This resemblance to chert has led to its being passed over without receiving attention. In some places, indeed, it is associated with chert, the two usually being confounded.

An analysis, made in Atlanta by Mr. J. M. McCandless, gave:

Calcium Phosphate (bone phosphate)	77.54
Iron and Alumina	1.50
Calcium Carbonate	6.83

Other analyses made in Nashville, show the calcium phosphate to range anywhere from 60 to 81 per cent., with varying percentages of iron oxide and alumina, but usually within the limits required.

Whence comes this phosphate? This involves two questions. First, whence come the layers of phosphate rock as we find them, and secondly, whence the calcium phosphate of which they are composed?

First, as to the origin of the layers; they are evidently a residuum left after a natural leaching of certain highly phosphatic limestones. The leaching has come from the long continued action of atmospheric waters upon the limestones, the carbonated waters sinking through the soil and, under the cover of the soil, dissolving away the calcium carbonate, leaving the less soluable layers of phosphate.

The limestones yielding the phosphate are undoubtedly of Trenton age. Among the divisions of the Nashville rocks of this age we have the following:

1st. *The Orthis Bed.* This represents a horizon easily recognized throughout the Silurian Basin of Middle Tennessee. The bed is about 60 feet thick. It gets its name from the fact that some of its layers are almost wholly made up of the shells of Orthis testudinaria.

2d. Next above the Orthis bed is the *Capitol limestone*, a granular, current-formed, and hence laminar limestone

showing cross-stratification. It gets its name from the fact that it supplied the rock for the building of the capitol at Nashville. Its grains are the fragments of comminuted shells, corals, etc., the whole once a drifted calcareous sand; hence its laminar structure and cross-stratification. Average thickness may be placed at about 60 feet.

3d. The *Dove Limestone*, a series 10 to 12 feet thick of mostly a compact, dove-colored limestone.

4th. Upon the Dove lies another division 28 feet thick, recently designated the *Ward Limestone*. Parts of this are much like the Capitol, laminated and showing current action.

All of these are more or less phosphatic, but it is the Capitol division or horizon which is the great source of the phosphate. Parts of this limestone show upon analysis from 15 to 25 per cent. of phosphate, the dark lines marking the lamination of the rock being especially rich. Throughout middle Tennessee, wherever the limestone has been subjected to the proper leaching conditions, residual fragments of phosphate may be found, the pieces often looking like sandstone, or like porous chert. About Mt. Pleasant the original limestone appears to have been especially rich in phosphate, though other localities may be discovered as good.

The Orthis bed lies under the masses of the leached out phosphate, and its outcrops, rich in Orthis shells, are a guide to them.

The Ward division, the 4th of the series above, also yields locally noteworthy quantities of phosphate, as does also the upper part of the Orthis bed.

As to origin of the phosphate in the original limestone, I can say but little. No theory presents itself that is satisfactory. A few specimens of Lingula and a few forms of shells allied to Cyclora have been observed to which may be added forms referable to conodonts. What a microscopical examination will reveal remains to be seen. The presence, accumulation and sorting of the phosphate would appear to have something to do with the currents that existed in the ocean when the matter of the rocks was undergoing deposition. We have said that the dark lines marking the lamination of the rock and due to the currents are especially rich in phosphate. These lines or seams, sometimes half an inch thick,

are seen on a dressed or weathered surface of the rock and are usually very rich in phosphate, often to the extent of 50 per cent. and more.

These masses of phosphate, like other residua, such as chert, etc., show the great effects of the long continued leaching of the rocks, by atmospheric and aqueous agencies, in this southern non-glaciated region.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Ein neuentdecktes Vorkommen von Tremadoc Fossilien bei Hof. By DR. J. F. POMPECKJ in München. In this paper Dr. Pompeckj gives an account of a newly discovered occurrence of fossils of Tromadoc age near Hof. The fauna of Hof was described many years ago by Barrande, and many of its trilobites referred by him to the genus Conocephalites. Since his descriptions were written several genera have been taken from this extensive genus, and Dr. Pompeckj's article is useful as showing how he refers the forms (or at least a number of them) which were placed in Conocephalites by the distinguished French palæontologist. *Conocephalites (?) munsteri, C. quaesitus* and *Calymne tristeni* var. *bavarica* are all included in Bavarilla hofensis, and *Conocephalites bavaricus* is removed to Dicelocephalus (?) *Conocephalites innotatus* and *C. discrepans* are transferred to Niobe.

In the cystidians and brachiopods we also note changes of genera. *Cystidea bavarica* becomes *Macrocystella bavarica* and *Lingula incohans* is called *Acrothele incohans.* The other Lingulas and Discinas remain generically as Barrande placed them.

In giving criteria for distinguishing Cambrian from Silurian faunas he refers Conocephalites and Olenus (as used by Barrande) Euloma, Bavarilla and Lichapyge to the former; Asaphus, Calymne, Lichas, Niobe, Amphion and Chirurus to the latter.

Dr. Pompeckj criticises a number of genera and sub-genera, proposed by Munier-Chalmas and Bergeron and compares them to Scandinavian and German forms.

The article closes with a description of the geological section at Neuhof, near Hof, where these fossils were found, prepared by Aug. Moroff. G. F. M.

Uber die Brachiopodengattung OBOLUS, *Eichwald.* By AUGUST MICHWITZ. This is an excellent and very comprehensive memoir on an important Cambrian (and Silurian) genus hitherto not fully understood. The work opens with a citation of authors who have written on the genus; a description is then given of the Cambrian terrain around the Baltic sea, and of the method followed in preparing the fossils.

A very full description is given of the outer and inner characters of the shells of this genus, and among other points it is to be noted that *Obolus quenstedti* (the reference of which to Obolus has been questioned by Hall and others) is accepted as a true and even typical example of the genus, being rated as a variety of O. apollinis. The genus Obolus is thus compared with Lingula and Obolella.

A full description of the different species of Obolus, as understood by Michwitz, is then given and several new species and varieties described. The following is the arrangement:

Sub-genus EUOBOLUS (n. s. g.) contains *Obolus apollinis* with three varieties, *O. triangularis* (n. sp.) and one variety, *O. panderi*, *O. schmidti*, *O. eichwaldi O. valborthi*, *O. elegans.*

Sub-genus SCHMIDTIA (Volb. gen.) contains *O. celatus* Volb., and two varieties, *O. obtusus* (n. sp.) and six varieties, *O. acuminatus* (n. sp.) and three varieties, *O. crassus* (n. sp.) and one variety.

Sub-genus THYSANOTUS (n. s. g.) contains *O. siluricus* Eichw.

Sub-genus LEPTUNBOLON (n. s. g.) has *O. linguaformis* (n. sp.) and one variety.

Sub-genus ACRITES (Volb. gen.) has *O. antiquissimus* and one variety.

This extensive and important work (216 pages, 4-to) is illustrated with three tables of finely executed figures, and seven cuts. G. F. M.

The Geological Structure of the Extra-Australian Artesian Basins. By A. GIBB MAITLAND. (Extr. from Proc. Roy. Soc., Queensland, vol. XII.) This paper, by the assistant geologist of the Geological Survey of Queensland, is devoted to an account of the artesian basins of the United States. The numerous quotations relate, naturally, to the western regions, the arid regions of Wyoming, the Dakotas, and northwestern Texas. At the same time some reference is made to the New Jersey artesian wells, and others of the Atlantic coastal plain. There are no original observations, the object of the paper being to review, for convenient reference by Australian students of artesian waters, what has been accomplished outside the Island Continent. J. F. J.

PERSONAL AND SCIENTIFIC NEWS.

JOSEPH LE CONTE sailed from New York on September 2d for Southampton.

MR. H. F. BAIN, Assistant State Geologist of Iowa, spent three weeks in September in northern Minnesota, in connection with a party of the Minnesota survey, who were reviewing some points of structural geology in the Archean and in the Animikie.

The American Institute of Mining Engineers met in Denver on September 21st for its seventy-first meeting. A large number of papers were presented, the following of which were more especially devoted to geology:

Gold in granite and plutonic rocks, *W. P. Blake.*

Rapid section work in horizontal rocks, *M. R. Campbell.*

Faulting and accompanying features observed in glacial gravel and sand in Southern Michigan. *Carl Henrich.*

Traces of organic remains from the Huronian (?) series at Iron Mountain, Mich., *W. S. Gresley.*

Magnetic observation in geological mapping, *H. L. Smyth.*

According to Mr. L. S. Griswold (Bos. Soc. Nat. Hist., May 14, 1895), the basin of the lower Mississippi did not exist until the close of Cretaceous time. The fold of the Appalachian Mts. swung westward as a land barrier until peneplained in Cretaceous time, and the waters of the upper Mississippi valley were emptied into a Permian and Mesozoic sea which existed toward the west. The post-Cretaceous elevation of the continent witnessed the extension of the river course toward the south instead of toward the west.

Mr. Lewis G. Westgate, in a report on the geology of the northern part of Jenny Jump mountain, in Warren county, N. J. (Report of the State Geologist for 1895), concludes that the white crystalline limestones of that county, and inferentially of Sussex county, are not of the same age as the blue limestones, but are pre-Cambrian, for the following reasons:

1. They differ lithologically from the blue limestone in being thoroughly crystalline and in containing large amounts of accessory metamorphic minerals.

2. They are intimately associated with and apparently interbedded with the older gneisses, and gneisses occur also interbedded in the limestones.

3. They show no intimate association in areal distribution with the blue limestone, nor any tendency to grade into it.

4. The metamorphic changes to which the white limestones have been subjected are general in their nature, and not due to the action of the eruptives by which they are cut, so that no sufficient agent is at hand to account for the supposed change from blue into white limestone.

The only apparent defect in the reasoning of Mr. Westgate seems to be in the assumption that the gneisses associated closely with the white limestones are pre-Cambrian. Further northeast, along the Appalachian fold are similar gneisses interstratified with a white limestone which is of Cambrian age (if not later) as proved by discovered fossils. We refer to the Stockbridge limestone and its extension southward to the New Jersey state line. There is no known reason for its termination at Sussex county, nor Warren county.

FIG. 2.

FIG. 3.

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THE ARLINGTON IRON—MINNESOTA NO. 2.

N. H. Winchell, Minneapolis.

(Plate X.)

This iron was found on the farm of Jos. Barry, Sr., two and a half miles northeast of Arlington, in Sibley county, Minn., in March, 1894. It was from the first suspected of being meteoric, but was not examined with care until the spring of 1896. A small piece having been broken off and submitted to Mr. Buck, of Arlington, it was forwarded to the writer for examination, after which the whole specimen was procured for the museum of the State University, where it is now preserved. The weight of the entire piece was 19¾ lbs. The following statement was given by W. J. McLeod, Esq., son-in-law of Mr. Barry:

Found in Sibley Co., Minn., on the farm of Joseph Barry, Sr., two and a half miles northeast of Arlington, in March, 1894. As it was found on a field that had long previous been cultivated, in the rich black soil and far from any highway, in a level country free from stone, it is confidently believed by the owners to be a meteor and the boy who found it, Joe Barry, Jr., expects it has some value as a curiosity.

Four and one-half pounds were broken by a sledge hammer from one corner, previous to which it was somewhat heart-shaped. The missing prong from this break was a precise counterpart in shape to the remaining one.

The following figure, (fig. 1) reduced to one-third the natural size, shows the shape of this iron, and the average thickness is about ½ inch. The upper (convex) surface is tolerably smooth, but has an indistinct, pock-marked aspect, due apparently to an internal crystalline structure, or to variation in the relative amounts of the ingredients. The lower surface, which is about a plane, is, however, curiously pitted and rough. Some of the pits are so deep as to nearly pierce the specimen. They are smooth, and conico-thimble shaped. This surface has, moreover, a thin scale, or rust, which suggests a mete-

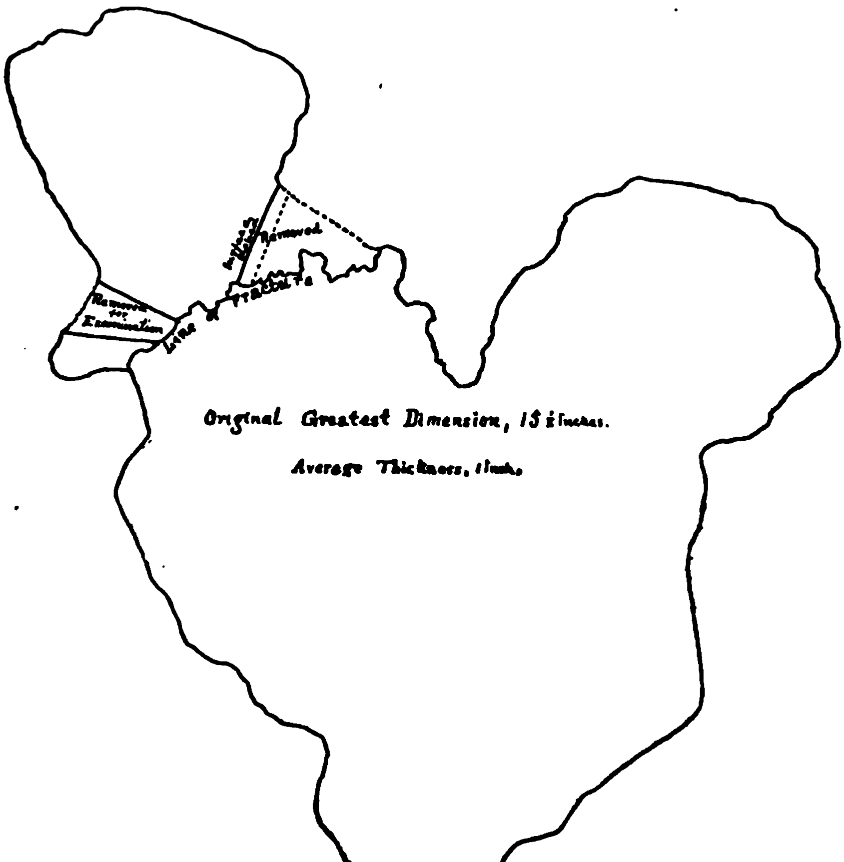

FIG. 1.

oric crust. This scale is best preserved in the depressions. The general appearance of the whole piece is that of a refuse piece of iron from a furnace.

On polishing a small portion of the upper surface and applying dilute nitric acid for a short time, the characteristic crystalline structure becomes beautifully expressed. Plate X, fig. 2, shows an etched surface, enlarged by photography two diameters. The rectangular figure in the lower portion of the plate, fig. 3, represents a portion, still further enlarged two diameters, taken from the etched surface at the place shown on the photograph.

Throughout the etched surface sharp ridges stand up, thus outlining the coarse Widmanstättian structure. These elevations, represented by the dark lining in both figures of plate X consist of some composition different from the depressions between them, for they not only resist the acid but they do not show the bright iron reflections that prevail in the depressions. These ridges are not entirely persistent and continuous, but disappear suddenly and rise again.

Between these long ridges the surface has, after etching, a brilliant metallic iron lustre, which is due to the reflection of light from crystalline lamellæ. These lamellæ are apparently cleavages that are in the Widmanstättian bands and they stand at different angles in different bands. They show that the bands themselves are crystalline throughout their substance. For instance, when placed in the direct sunlight the position at which the lamellæ marked at *a* are most illuminated by reflection is about 45 degrees different from that in which the rest of the long lamellæ are illuminated. That system of coarse lamellæ which is in the lower left hand corner of figure 3, in like manner consists of two series. The broader upper band reflects light in a position at an angle of $90° \pm$ from that at which the rest of the associated lamellæ reflect it. The same fact is observable in other parts of the etched surface.

These fine lamellæ, however, which might be called cleavages, and which characterize the metallic depressions, are crossed by a fine striation wholly independent of the long Widmanstättian structure. This striation is shown in the photograph and in the enlargement. In most of these

metallic surfaces this striation runs in the same direction, but in the bands at *a* it is at a different angle with the grand structure. This striation, in like manner, consists of dark ridges separating metallic grooves. They seem to differ from the coarse structure only in being much finer. Thus this iron has not only a coarse Widmanstättian crystallization, each band being, as it were, an individual crystal, but it has what might be considered a fine cleavage and a minute internal structure, which, throughout the separate crystals, maintains its direction and individuality.

These finer markings suggest those described by J. Lawrence Smith and named Laphamite marks,* but they seem to differ from them in an important manner, if they be compared with the description published by Smith, yet there is no doubt that they both are due to a fine internal structure of the iron itself. The reflecting cleavages do not indicate any variation in the composition of the iron and are more likely to represent the markings noted by Dr. Smith, but the dark elevated ridges, both coarse and fine, are apparently of a different chemical composition.

An analysis was made by F. F. Sharpless, and the following was the result:

Analysis of the Arlington Iron.

Sulphur	none
Silicon	none
Manganese	none
Chromium	trace
Copper	trace
Carbon (combined)	trace
Iron	90.781
Nickel	8.605
Cobalt	1.023
Phosphorus	0.045
	100.454

Mr. Sharpless adds:

The only way in which I can account for the excess over 100 per cent. is that the composition does not appear to be uniform. Four determinations were made for iron, giving results varying from 90.58 per cent. to 91.74 per cent. In the attempt to make a carbon determination the variation in composition was also noticed. Of three samples, weighing about three grammes each, treated with potassium-copper chloride, one

*Am. Jour. Sci. (2), XLVII, 271; ibid. (3), X, 351.

sample gave a particle of carbon much larger than a pin-head, one sample gave two small specks, while the third dissolved without giving a trace of carbon. When treated with hydrochloric acid all samples, with the exception of one, dissolved without giving evidence of combined carbon: this one sample gave a very strong odor resembling that given off when dissolving steel in hydrochloric acid.

About three grammes were used in making the tests for the metals noted as "none" or "trace," or sufficient to be sure that the results given are very nearly correct.

This supposed variation in composition is in keeping with the spotted appearance of the weathered convex surface of the specimen.

THE AGE OF THE CALIFORNIA COAST RANGES.

H. W. FAIRBANKS, Berkeley, Cal.

In a recent paper devoted to a criticism of the theory of isostasy Mr. F. Leslie Ransome* treats of the subject as exemplified in the formation of the Great Valley of California. He reaches the conclusion that the principle of isostasy is insufficient to account for the formation of this valley and the Coast ranges bounding it on the west.

It seems to the writer that the evidences given in the above paper in favor of the view taken are well supported by the facts, and he is in hearty accord with the main conclusions, but the discussion of the history of the Coast ranges as intimately related to this question could have been made much more effective, and have strengthened Mr. Ransome's position materially, if he had taken pains to acquaint himself more fully with the recent literature bearing on the geological history of the Coast ranges.

The writer agrees with Mr. Ransome that the history of these ranges is as yet very imperfectly known, but nevertheless, a large mass of facts has been accumulated bearing upon it which are diametrically opposed to the assumption which he makes of a post-Miocene age. That the Coast ranges originated at the close of the Miocene is the opinion which was held by the older geologists, but since their time there has been a great increase in our knowledge of this field, and we now have good reasons for believing that the structure and history of the Coast ranges are not so simple, nor the date of

*Bull. Dept. Geol. Univ. Cal. vol. 1, pp. 371-428.

the formation of its axis as a whole, so recent as was formerly supposed. In the light of our present knowledge a return to the earlier opinion is very surprising.

The statements in Mr. Ransome's paper to which the writer wishes to call especial attention and to which there are the most weighty objections are the following:

"It is very doubtful whether anything at all comparable with the present valley existed during Cretaceous times.....At Paskenta on the west side of the Sacramento valley there is a great thickness of Cretaceous strata exposed, dipping steeply toward the valley. Mr. Diller referring to these strata, speaks of over 29,000 feet of sediments (Shasta-Chico series) being laid down in the Sacramento valley, but he probably hardly means to convey the impression that there was then any distinct valley. No such thickness of Cretaceous rocks is found on the eastern or Sierra Nevada side of the valley, and we should rather suppose that the sediments observed at Paskenta thin out under the present valley, and that their greatest thickness, and therefore the deepest depression in which the Cretaceous sedimentary lense was being deposited, was either at the above named place or even at some place west of it, over the site of the present Coast ranges. In the latter case the strata have probably been largely removed by denudation. Throughout the Coast ranges the Cretaceous strata are so widely spread, and so considerable in volume, as to indicate that the region occupied by these mountains was not only submerged at that time, but was probably more deeply submerged than was the area of the present Great Valley.

During the Eocene (Tejon), according to Mr. Diller, northern California and a large part of Oregon were above sea and being degraded, no Eocene deposits being known in California above the 40th parallel. There was probably a gradual subsidence, as shown by the thinning out of the Tejon northward in California. But so much being granted, there is nothing to indicate that any step had been taken toward the initiation of the upper Sacramento Valley, while to the south of the 40th parallel the probabilities are that the sea had an almost or wholly unbroken sweep across the area now occupied by the Coast ranges and the Great Valley....It is possible that with further knowledge of the mountain ranges inclosing the Great Valley we may be able to trace in Miocene times the first faint boundaries of the whole or part of the valley as known to us to-day, but at the present time we must agree substantially with Antisell in considering that 'probably during the whole of the Miocene the Coast range was altogether beneath the sea-level,' and take up its history at a point subsequent to that time.

The occurrence of a great orogenic disturbance at the close of the Miocene, giving birth to the Coast ranges as a connected mountain chain, appears to be one of the best established facts in the geology of California. From that disturbance dates the history of the Great Valley.... According to the U. S. Geological Survey the Great Valley was probably occupied during the whole of the Neocene by a gulf, connect-

ing with the ocean by one or more sounds across the Coast ranges,—which is in general harmony with the foregoing.... It will be seen from the foregoing that up to the beginning of the Pleistocene, the area now occupied by the Great Valley was at no time the theatre of particularly heavy sedimentation or active subsidence. There is evidence that during the Cretaceous and Miocene the heaviest sediments and deepest depressions lay to the west of the present valley, and along the line now occupied by the Coast ranges."

It seems also that a similar view has recently been expressed by Prof. Lawson* as the following quotation will show.

"The granites of the southern and northern Coast ranges seem to be geologically continuous with those of the Sierra Nevada. The fact that the Sierras are separated from the Coast ranges by the valley of California is immaterial to the discussion, since the latter is clearly a delta-filled geo-syncline of late Tertiary or post-Tertiary origin."

We will first take up a consideration of these statements and then proceed to show the evidence for the existence of a Coast range axis undergoing oscillations not only through the whole of the Cenozoic but also the greater part of the Mesozoic.

An examination of the Great Valley reveals the fact that while the post-Jurassic sedimentary terranes along the foot of the Sierras are not greatly elevated or prominently exposed, there is found on the contrary on the eastern flanks of the Coast ranges a great thickness of sedimentary strata varying in age from the lower Cretaceous up through the Miocene. These have been greatly elevated and dip under the valley at varying angles. Although there is only one spot (Marysville buttes) where any of them are exposed in the centre of the valley, yet all considerations lead us to believe that the greater portion of the region which is now embraced within the Great Valley has been subject to continuous sedimentation from Cretaceous times down through the Miocene, and probably at intervals through the Pliocene. The writer does not know of any reasons for doubting that this condition of things obtained in the Great Valley during the period mentioned. But what of the Coast Ranges? Were they non-existent prior to the Miocene as the authors quoted would have us believe, with an open sea bathing the base of the Sierra Nevadas, or are there good evidences of a northwest and southeast land barrier through the Coast Range region which was probably

*AMERICAN GEOLOGIST, vol. xv. p. 346.

then and is still related to the mountains of southern California? If it can be shown that the different aggregates of strata occurring there, and representing the main geological divisions from the Jurassic, or even earlier, are separated from each other by non-conformities, there are then the most excellent reasons for believing that, in marked contrast to the Great Valley which was probably continuously beneath the sea, the Coast Range region has been subject to repeated axial elevations and depressions, now above the sea, now more or less submerged. We must not think of these movements as of a uniform character, affecting all parts alike, but while orogenic, or even epeirogenic in extent they were also locally intensified.

In all probability the sag once inaugurated between the two great ranges constituting what has been termed the Great Valley has never been structurally obliterated.

Nothing is clearer in the study of the Coast ranges than that there have been enormous movements of the coast as a whole, as well as differential movements of large magnitude, whereby new local ranges have been formed by the side of more ancient ones without greatly affecting them.

The supposition which Mr. Ransome advances concerning the possibility of the Cretaceous sediments having been deposited in greatest thickness over the region now occupied by the summit of the Coast ranges is hardly supported by the facts. It is possible that the sediments may once have mantled over a portion of what is now the Coast ranges west of Colusa county, but it is quite certain that the region toward the coast was above water because of the entire absence of the lower Cretaceous and the fact that the Wallala beds rest directly on the Golden Gate series with a basal conglomerate.

The statement in the quotation from Mr. Ransome that Mr. Diller probably hardly means to convey the impression that there was any distinct valley during the Shasta-Chico deposition is rather strange in the light of the following quotation from the same paper of Mr. Diller* where in speaking of the view held by Fairbanks that the Coast ranges and the Sierras were upheaved at the close of the Jurassic he says:

*Bull. Geol. Soc. Am. vol. v, p. 455.

"There is evidence favoring the same conclusion in that the thickness of the Shasta-Chico series diminishes westward from the Sacramento valley into the Coast range, as it does eastward to the base of the Sierra Nevada.—The thinning out of the Shasta-Chico series westward from the Sacramento valley shows that the Coast range was uplifted at the close of the Jurassic, when the Sierra Nevada received its final folding and the Great Valley of California was outlined thereby. It cannot yet be definitely concluded that the Coast range and the Sacramento valley originated at the close of the Jurassic; their beginnings may date from earlier foldings; but whatever the date of inception, it is evident that during the Shasta-Chico period the Coast range existed, but did not furnish sufficient obstruction to keep the open sea out of the Sacramento valley. for the fossils of that period are everywhere purely marine."

Although the Cretaceous is found at widely separated points through the central Coast ranges there is every reason to believe that much of the region was above water through not only the Cretaceous, but also the Eocene. If the Coast ranges originated as late as the close of the Miocene how is it possible to explain the fact that in different portions the strata of this age rest unconformably on either the Tejon, Chico, Knoxville, Golden Gate series, or the crystalline basement rocks, as the case may be? While all the main geological divisions from the Jurassic down appear in the Coast ranges they are all rarely present in a single locality.

The quotation given by Mr. Ransome from Antisell shows the limited knowledge of his day, for a little farther along he says that the earliest strata brought to light by the Tertiary elevation are of Miocene age.

It is difficult to see the harmony which is stated to exist (p. 386) between the quotation from the U. S. Geological Survey to the effect that during the Miocene the Great Valley was occupied by a gulf, connecting with the ocean by sounds through the Coast ranges, and the statement by Mr. Ransome that "the Coast ranges were altogether beneath the ocean, deeper submerged in fact than what is now the Great Valley."

As a true conception of the age of the Coast ranges, as well as of the many oscillations of level recorded by their strata, is of the utmost importance for California geology it seems best to restate briefly what is at present known bearing on this subject.

In discussing the geological history of the Coast ranges, or of any mountains for that matter, it is very necessary to keep in mind the fact that the mere accident of level at which the sea stands has no real bearing upon the significance of corrugations on the earth's crust. A mountain range is the result of certain structural conditions of the crust and must be considered, at least from the point of view of this discussion, as such, whether totally submerged, whether partly so or wholly above the sea.

Dall and Harris* have made the following observation concerning the more recent disturbances in the Coast ranges:

"The fluctuations and changes of level which have characterized the coast of this region since the beginning of the Neozoic, as the fossils prove, can hardly be realized except by the observer in the field, and any attempt at description would read like the vagaries of a vivid imagination."

Prof. Lawson† has also emphasized this same idea in the following words:

"From the earliest condition of which we have any record revolution has followed so closely on the heels of revolution, and each has effected such radical changes in the preceding set of conditions, that it becomes clear that the term "event" can only be used by reason of its convenience, and that what we call events are but the culminating phases in a wave of diastrophic action which seems never to have ceased."

The more we study the geological history of this region the more we are impressed with its exceeding complexity.

Pre-Jurassic Complex. The pre-Jurassic basement rocks comprise granite, crystalline schists and marble. They extend from Bodega head on the coast of Sonoma county in a southeasterly direction, though not outcropping continuously, and probably join the older rocks of the San Emedio mountains. No remnants of uncrystalline strata are associated with this complex, and it must be admitted that through some long protracted interval antedating the Jurassic these rocks formed an elevated mountain range exposed to erosion.

Upper Jurassic. Resting on these ancient crystallines and underlying nearly the whole of the region of the Coast ranges south and west of the Klamath mountains, is a series of rocks to which the writer has given the name of the Golden Gate series.‡ Accumulating facts point to the truth of the view

*Bull. 84, U. S. Geol. Surv., p. 198.
†XV Annual Report, U. S. Geol. Surv., p. 465.
‡Journal of Geology, vol. III, p. 416.

first advanced in 1892, that the first great upheaval of the Coast ranges to form a system of mountains having proportions anything like those of the present day was synchronous with the post-Jurassic upheaval in the Sierra Nevadas and Klamath mountains.

The source of the sediments constituting this series was, in the central Coast ranges at least, the pre-existing granite axis. Along the coastal slope of the Santa Lucia mountains in Monterey county conglomerates outcrop at the base for a distance of nearly eight miles. Recent observations have shown that similar beds occur along the Sur river. At Point San Pedro and on the north side of Montara mountain, as first described by Lawson* and Ashley,† is a series of rocks which in the writer's opinion are of the same age as those in Monterey county. The latter also rest against the granite with a basal conglomerate. A large part of the boulders and pebbles of all three occurrences are derived from the rocks on which they rest. These facts are sufficient to establish the existence of a pre-Jurassic land area in the region under discussion.

Lower Cretaceous. The Knoxville beds have been detected in the Coast ranges from Santa Barbara county on the south to Tehama on the north. They rest unconformably on the older and more metamorphosed Golden Gate series, which in marked contrast has undergone much more violent disturbances, so that its structure is in many cases most difficult of elucidation. The writer feels assured that the reality of this non-conformity cannot be doubted by any one who will take the pains to examine the relation shown in different areas previously described, or in fact in any section of the Coast ranges where the two series of beds come in contact.

Accepting the present classification of the Cretaceous, the Golden Gate series belongs in the Jurassic and probably in its upper portion. Before the deposition of the Knoxville it had been lifted above water and subjected to erosion through the whole area of the Coast ranges. So complex have been the movements in this region that it is rather difficult to form an idea of the geography during the Knoxville period. The

*American Geologist, vol. xv, June, 1895.
†Journal of Geology, vol. iii, p. 435.

remnants of these beds yet remaining indicate that a part of the region was then depressed beneath the sea. Basal conglomerates as extensive as those in the Golden Gate series have not been found, although Diller* describes local conglomerates and coarse sandstone at the base of the Knoxville in northern California, while the writer has observed the same thing at and near the base of the beds of this age in San Luis Obispo county. The distribution of the Knoxville, as well as the fact that at many points the Chico rests directly on the Golden Gate series, is good evidence that the whole of the area of the present Coast ranges was not submerged.

Chico. While a general subsidence through the Shasta-Chico period of deposition is shown by Messrs. Diller and Stanton for northern California and Oregon, it is quite clear that, through the central Coast ranges, at least, a stratigraphic break is discernible. In the Chico sandstone predominates in many places, while in the Knoxville shale is the most characteristic. In portions of the southern Coast ranges the Chico contains vast beds of conglomerates. In the upper portion of the Sisquoc cañon, in northern Santa Barbara county, granite boulders, sometimes nearly two feet in diameter, occur in these beds. Along the lower portion of the Cuyamas valley cliffs facing the river and rising several hundred feet are formed largely of conglomerates. Farther north the conglomerates rest on the granite of the San Jose range. It seems probable that this range extended to the San Emedio mountains during the Chico and that the conglomerates were formed near a shore line. In central Santa Barbara county there is an extensive body of conglomerate hundreds of feet thick which appears to form the dividing line between the Knoxville and the Chico. Farther north the basal portion of the Chico consists of sandstone, which rests unconformably on either the Knoxville or the Golden Gate series. Diller has noted similar conglomerates at the base of the Chico in northern California and considers that they may be due to topographic changes resulting from the intrusion of the peridotites. We have clear evidence then of extensive land areas in the Coast ranges during the upper Cretaceous.

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*Bull. Geol. Soc. Am., vol. v, p. 463.

Eocene. The Tejon beds have generally been considered as conformable upon the Chico. In Oregon Mr. Diller* has shown that a break exists, the underlying Shasta-Chico series being much more disturbed. There are evidences however through the central Coast ranges of a stratigraphic break, for while the Tejon occurs only sparingly the Chico is widely distributed. Should a break be demonstrated it is indicative of an upward movement of the region, leaving much more of the land above water during the Tejon than the Chico.

The northernmost known occurrence of the Tejon in the Coast ranges is about Clear lake. From Mt. Diablo southward it is well developed on the eastern flank of the Coast ranges and at several points near the coast-line. It is developed in greatest extent in northern Ventura and eastern Santa Barbara counties. On Carmello bay there are bodies of sandstone and conglomerate, the latter consisting partly of pebbles of the granite on which it rests. It is referred provisionally by Lawson† to the Tejon. A similar sandstone has been observed south of Point San Pedro by the same geologist.‡ The great development of the Tejon at the southern end of the Coast ranges gives plausibility to the idea that the Great Valley had connection with the ocean at this point during the Eocene. The presence of the Tejon on the eastern slope of the Coast ranges for a long distance and its rare occurrence within the area of these ranges makes it probable that they were much more elevated than during the preceding Chico or the following Miocene, and that this land area connected with the Klamath mountains on the north. It is inconceivable that, if the Tejon once covered the Coast ranges, it should have been so completely removed from almost all interior points.

Miocene. There is strong evidence that previous to the beginning of the Miocene sedimentation a marked subsidence took place through the central and southern Coast ranges, while in northern California according to Diller§ the Miocene was inaugurated with no great disturbance unless a slight

*Bull. Geol. Soc. Am. vol. IV, p. 219.
†Bull. Dept. Geol. Univ. of Cal. vol. I, p. 19.
‡XV Annual Report of U. S. Geol. Sur. p. 458.
§XIV Annual Report U. S. Geol. Sur. p. 425.

depression. Land existed in the Klamath mountains but it was not greatly elevated. Becker* has held that land existed also in the Clear Lake region during the Miocene. From the region of San Francisco bay southward it appears that at the beginning of the Miocene there were numerous detached land areas extending in the direction of the San Emedio mountains, which although now rising 9,000 feet were then nearly submerged. At the base, the Miocene consists very generally of a coarse arkose sandstone or conglomerate. These shore deposits occur in many places, a few of which will be enumerated. They are found along the flanks of the Santa Cruz range, in Alum Rock cañon on the northern slopes of the Mount Hamilton range, east of Monterey in the Palo Escrito hills according to Whitney,† along the slopes of the Santa Lucia range in southern Monterey county. etc. The almost buried granitic axis extending from the Santa Lucia range to the San Jose range in northern San Luis Obispo county is bordered for nearly 100 miles by coarse arkose sandstones and conglomerates derived from the granite on which they rest. Much of the southern and western sides of the San Joaquin valley is bordered by argillaceous sandstones and clays of Miocene age. They are richly impregnated with alkalies, indicating deposition in quiet waters partly shut off at least from the open ocean.

The facts at present known seem to warrant the statement that at the beginning of the Miocene the region of the central and southern Coast ranges was occupied by an archipeligo of islands, some of them being of large extent. Enough is known of the Miocene to trace out the position of these areas with some accuracy but it will not be attempted here.

In the foregoing presentation of a few of the facts bearing upon the history of the Coast ranges the writer hopes to have shown reasons for believing in a great age for this system of mountains. The mere fact that a subsidence took place at some period, even if as a result the mountains wholly disappeared beneath the sea, is no reason for affirming that the mountains first originated with the following re-elevation. The upheaval at the close of the Jurassic in all probability

*Quicksilver Deposits of the Pacific Coast, p. 238.
†Geol. of Cal., vol. I, p. 154.

gave the Great Valley a form approximating that of the present day, and there is every reason to suppose that this valley has been subject to continuous sedimentation up to within comparatively recent geological times. But whether continuously submerged or not, when once the folding of the crust was initiated along the axis of the Coast ranges it is in the last degree improbable that the axis has ever been wholly obliterated.

Summary. In the Coast Range region a granitic axis is recognized as existing above water and undergoing erosion in early Mesozoic and possibly Paleozoic times.

Preceding the deposition of the Golden Gate series, which is believed to represent the upper Jurassic, a subsidence took place continuing with oscillations to the close of that period.

At the termination of the Jurassic occurred the great upheaval of the Sierras and Coast ranges. The Golden Gate series after being uplifted and folded was subjected to a considerable interval of erosion, following which another depression took place.

The Cretaceous was ushered in with a sinking land. This continued through the Knoxville when another elevating movement was experienced. Through the central portion of the Coast ranges the Knoxville was thus subjected to disturbances and erosion, causing a stratigraphic break between it and the Chico. During the latter period a subsidence was again inaugurated until the opening of the Eocene when the re-elevation of the land in northern California was probably felt through the whole of the Coast ranges.

At the close of the Eocene we have evidences of a renewed disturbance which resulted in the strata of that age being folded, uplifted and exposed to erosion.

Miocene sandstones are found resting with marked nonconformity on the Eocene in the southern Coast ranges, pointing to the fact that still another depression had been experienced with the opening of the Miocene. Sinking continued through this period and at the time of change of sedimentation from sandstone or clay to the bituminous shales, extensive movements similar in character to those shown in the Golden Gate series must have taken place. The Miocene was terminated by one of the most marked changes of level record-

ed in the history of the region. This change was in the nature of a great uplift, with the formation of several new ranges.

During the Pliocene the region was again depressed. This was followed by another marked elevation which has continued with some irregularity, and perhaps local depression, up to the present day.

In this outline no attempt has been made to trace the character of the movements, but simply to call attention to the complex relations of the different series of strata, with the object of showing the existence of mountains in the region of the California Coast ranges in much more remote geological times than Mr. Ransome is willing to grant. The five or six marked non-conformities between the different series of strata are indubitable evidence of the existence, periodically at least, of a connected series of mountains above the sea level.

It is difficult to understand how the principle of isostasy can be reconciled with this remarkable series of oscillations along the coast of California. A criticism of the theory taking into account the history of the Coast ranges must be greatly strengthened.

THE ELECTIVE SYSTEM IN ENGINEERING COLLEGES.*

By M. E. WADSWORTH, Director of the Michigan Mining School.

It was my privilege to present for your consideration last year a paper on the elective system as adopted in the Michigan Mining School; it is now my purpose to continue this subject by presenting some further particulars and pointing out the conditions under which this system might with great advantage be introduced into other engineering colleges.

To establish a clear understanding between the auditor and myself, I shall divide the matter up into heads which are regarded as cardinal points in the argument.

1. Engineering is a Learned Profession.

This I think will be admitted without discussion, hence it clearly follows that studies forming integral parts of the

*Read before the Society for the Promotion of Engineering Education. Buffalo, N. Y., August 20th, 1896. (Abstract.)

course in all engineering colleges are just as truly professional studies as are those given in schools devoted to theology, law, and medicine. Those who follow the last named professions have certainly not excelled the engineer, if they have equalled him, in the task of promoting the happiness, welfare and morality of mankind; nor can it be proven that success in either of these professions requires deeper study, higher intellect, more experience with men and things or better balanced judgment, than is needed for the successful presentation of engineering projects. Why, then, does the public at large hold the engineering profession inferior to the others just mentioned? I answer, because we ourselves have set them the example and they accept the engineer at our own valuation. Educators have, unconsciously, perhaps, but none the less truly, proclaimed their own conviction of the inferiority of an engineer's mental needs and equipment by the introduction and continued retention of

II. *Non-essential Studies in Engineering Courses.*

This mistake naturally arose from the fact that the early engineering schools or courses were planned in the now clearly erroneous assumption that their training must include a so-called liberal education, or else prove itself to be the equivalent of the classical courses then in vogue. Further, most of these early engineering courses were grafted into older institutions, under control of a literary or classical faculty, men whose very training and success in their chosen lines unqualified them to perceive that the study of engineering, if properly conducted, affords just as rigid, logical and powerful a mental training as can be obtained through the study of any other subjects whatever.

The engineering faculty, and they alone, are the parties competent to formulate the list of studies for engineering students, and their decision in such matters must be final, if engineering courses are to be freed from driftwood and barnacles.

III. The Natural Sequence of Studies must be Observed.

It is objected by many (1) that under the elective system the student will receive only a disorganized course, and (2) he will finally graduate with a training which is insufficient, because it lacks both depth and comprehensiveness. Neither

objection is sound, if the course is in competent hands. The professor of each branch unquestionably knows what subjects a student must have mastered in order to profit from his own instruction, hence if he rigidly demands these, his students must necessarily have received a systematic and thorough training in everything having a real bearing on any work they elect to take up. Strict observance of the sequence of studies will with mathematical certainty force each student to go thoroughly over every subject preparatory to every other subject elected, hence a disorganized course becomes impossible. It thus appears that by this system, depth is not sacrificed but rather increased.

Lack of comprehensiveness is easily and effectively guarded against by demanding for graduation as many courses as a good student can successfully carry in the time usually available for a college course. Indeed, if the natural sequence of studies be rigidly observed, it is advantageous and perfectly feasible to throw down the artificial barriers that have grown up between the different branches of engineering and thereby allow the students to enter upon a general engineering training, without any sacrifice of thorough work, or any friction between various departments. Students could select courses in harmony with their dispositions and abilities; the differentiation would take place naturally. While the degree would not mean that all had taken the same studies, it would mean that every study taken had been prosecuted with success. Further, it would mean that the student has received a better training for his life work than can be given under any rigid or optional system. Quality, not quantity, is the distinguishing feature of this plan.

There is no reason whatever why the elective system should be confined to engineering colleges alone of professional institutions. If the sequence of studies, which is to the elective system what the keystone is to the arch, is rigidly observed, the system could with advantage be introduced into law, medical, theological, or other professional colleges.

IV. The Elective System clearly shows up inferior Teaching, superfluous Subjects and incompetent Professors.

As each professor rigidly demands proficiency in all branches preparatory to his subjects, every student in a class must in

a measure serve as an exponent of the ability, thoroughness, or honesty of such other professors as have had charge of his previous studies. Any evidence of general inferiority in training in any one subject is quickly detected, and the remedy should be promptly applied.

Should a professor introduce courses foreign to the work of the school, the fact is quickly made apparent because no other professor prescribes such courses as preparatory to his own, nor do the students elect them. Hence this system does away completely with all padded courses, incompetent instruction, or irrelevant matters given merely to fill in a certain amount of time. It makes such instruction serve as a check on the proficiency of the others, produces a co-ordinate system of studies, and renders possible educational results which under the old systems would demand a much larger faculty.

V. *The Elective System is the only one which can make full Provision for the differences in Temperament, Taste and Talents, which must always exist between the various Members of the Student Body.*

Under the elective system the student selects that work for which he has been properly endowed by nature; he takes far greater interest in it, and the results are deep and permanent. So marked is this that no instructor in the Michigan Mining School now hesitates to demand of his men far higher and better work than even the most sanguine could ever hope to get under the old rigid system. Even if the elective system does demand higher work in each branch, and a more proficient preparation for each study, the student himself readily sees the object and justice of each requirement, and cheerfully accepts an obligation carrying with it freedom in choice of studies and avoidance of non-essential ones. All this acts like oil upon the machinery and enables the product to be turned out with little noise, friction and wear and tear.

Since engineering is largely a matter of economics, is it not wise to have the student make the first application of this principle when expending his own energy and time?

VI. *Certain Conditions are Essential if the Elective System is to be a Success.*

It must be clearly recognized that every educational institution has its individual peculiarities, hence before undertaking the introduction of a new system, or a modification of an

old one, every school must make an exhaustive inquiry to determine the relations between the proposed course and its environment, constituency, faculty, trustees, equipment, object, etc. That scheme most in harmony with these should be adopted, and in determining which one most nearly meets the required conditions, nothing is more necessary than a liberal use of that very rare commodity, common sense.

It is surely unnecessary for me when addressing a body of engineering educators to point out the uselessness of mere copyists or servile imitators; temporary success may crown their efforts in some cases, but not one like this, because in every problem the requirements are so diverse. In every case the scheme must be worked out anew in every detail from the very foundation.

Every educational scheme, and the elective system more than any other, demands for success that schools be conducted on sound business principles. The governing board must be composed of experienced, able, judicious, and conscientious men; they need not of necessity be educators or engineers, but they should have the wisdom to perceive that the successful direction of a higher educational institution requires experience and ability on a par with that demanded in any other business or profession. They must realize that no success can crown their efforts unless they clearly understand that their duty consists entirely in formulating the objects of the institution, providing the means to reach these objects, choosing an able and discreet director or president and seeing that he attends to his duties. Assumption of any other power is mathematically certain to cause friction and throw painful obstacles in the way of progress.

The success of the institution depends largely upon the chief executive officer and the faithfulness with which he is supported by the board and faculty. The president need not of necessity be an engineer, but it is absolutely indispensable that he be an able and experienced educator, a man of broad gauge, liberal spirit, unbounded energy, perseverance and firmness. To him should be left, without any interference whatever, the carrying out of the plans formulated by the board, and he should be held strictly accountable for results. Nothing short of incompetence should be deemed a sufficient reason for interfering with his plans.

The president must make a study of the institution as a whole; formulate the results to be reached by each official of the school in order to carry out the general scheme; see that these results are obtained, be empowered to discharge, without recourse to others, any official found to be incompetent. He must allow each of his associate officers full liberty to reach in his own way the results demanded of him, rigidly abstain from interfering with his work and aid him whenever possible.

VII. The Advantages of the Elective System.

They may be briefly enumerated as follows:

(a) It lightens the labor of the instructors, i.e., removes much of the drudgery, makes the work far more a labor of love and enables each one to give as extended a course in his department as he wishes without interfering with another professor.

(b) It greatly reduces the friction between faculty and students, almost does away with faculty meetings and renders the necessary regulations few in number.

(c) It renders examinations almost unnecessary, grades the student by his daily work; removes the padding of courses, shows up inefficient teachers and allows the professors and the institution to get rid of incompetent pupils with almost no friction.

(d) It results in better and higher work in each subject, and develops the best that is in each student.

(e) It is more economical both in money and time than either the required or optional systems, i. e., a smaller faculty accomplishes the same results.

(f) It enables an instituiton to keep pace with the rapid development of the various branches of engineering without the introduction of new faculties and new degrees with all their attendant evils.

(g) It serves as a safety valve for the students' pent up energies, and almost does away with class rebellions, especially those due to some particularly obnoxious professor, or to the suspension of some popular student.

(h) It does away with the practice of hazing and most of the other disgraceful customs of students in educational institutions; it renders the student more manly, and in a professional school allows a man to attend to athletics and his studies without that demoralizing sacrifice of truth so fearfully prevalent.

(i) It proclaims to the public, and with perfect truthfulness, that not only has the student "gone through" certain studies to obtain a degree but each of those studies has "gone through" him; in other words, that no student has been allowed to slide through some studies in which he was weak because there were others in which he was proficient, nor has he been graduated simply because of his excellence in athletics.

(j) It unites into one harmonious whole the studies that are usually classed as undergraduate to those that are called graduate, and leads the student to consider them all as a desideratum for his work. It broadens his field of view, inclines him to pursue further study, and diminishes his tendency to contract the megacephalous disease.

VIII. *Experience in the Use of the Elective System at the Michigan Mining School.*

When I assumed the position of director of the Michigan Mining School nine years ago the institution was in its infancy and no systematic course of instruction had been laid out. The rigid system usual in engineering schools was the only one then available and it was accordingly introduced. The rapid development of the school soon pushed this system to its ultimate results, namely, the wishes of each member of the faculty as to the work he thought should be given in his department were gratified. There resulted in consequence an engineering course which could be successfully coped with only by one exceptionably able both mentally and bodily.

Every instructor realized that the system was crushing under its own weight, and that prompt relief was imperatively necessary. When casting about for a solution of the long foreseen difficulty, the director, among other things, interviewed each member of the faculty separately as to his views on the desirability and practicability of an elective system. The concensus of opinion was that such a system, while advantageous in a literary institution, presented insurmountable obstacles to its introduction in a technical institution like the Michigan Mining School. The director, however, saw no other solution to the difficulties then encompassing the course of study, and, notwithstanding the discouraging outlook, determined to test the practicability of laying out a suitable scheme; from time to time he consulted each instructor as to his wishes in all matters relating to his department. After several months' labor the details of the plan were finally worked out, obstacles surmounted, conflicting interests harmonized, and the completed work submitted to the faculty and the board. It was promptly and unanimously adopted by both bodies and has proven to be the greatest single advance the Michigan Mining School has ever made.

The faculty meetings have been reduced from one or more weekly to five in forty-five weeks, and unless some emergency arises, one or two meetings a year will be all that will be necessary in the future to transact the business that is required of the faculty as a body.

The system has also brought about a simplification of the other work and enables it to be rapidly done because the director is charged with the duties that usually devolve upon a faculty, and because each professor has absolute control over his department and the students in his classes. The head professors are responsible to the director while the other instructors are directly responsible to the head of the department with which they are connected.

The regulations of the school have been greatly reduced in number and so arranged that the student himself is specially interested in seeing that they are observed, since if they are not, his own act walks him out of the institution and closes the door behind him, in most cases without the intervention of the faculty or director. Those of you who have debated long hours over some student, whether it was "to be or not to be" can realize what a relief such automatic action is for a long suffering faculty. These changes have all naturally grown out of the elective system, and the result is that the Michigan Mining School has had one of the pleasantest, most profitable and harmonious years it has ever seen, although it has never developed enough disturbance in its history for the newspapers to take up its discussion. Not a single professor or student desires or would go back to the old system, and while further experience will undoubtedly indicate various modifications of details, it can certainly be considered at this time that the elective system is an unqualified success.

OROTAXIS: A METHOD OF GEOLOGIC CORRELATION.

BY CHARLES ROLLIN KEYES, Jefferson City, Mo.

In his discussion of the ancient formations of the Lake Superior region the lamented Roland D. Irving* lays particular stress on the value of unconformities as a basis for geological

*U. S. Geol. Sur., 7th Ann. Rept., pp. 390 399, 1888.

classification. In the application of the principle to the region that was under consideration it was shown that unconformities were the most important of all criteria in resolving into its grander subdivisions a vast sequence of crystalline rocks which, as in the case of other similar masses, had defied all attempts at satisfactory arrangement and correlation. Had he not been so untimely called from his field of labor he might have expanded his theme so as to be of much wider, if not of universal application. It is not that Irving was the first to suggest the use of unconformities in delimiting the grander geological formations, for this at the present time is essentially the real foundation of our accepted geological classification. Other criteria, however, have so overshadowed this one that the fact of its ever having assumed an important role is well-nigh lost sight of entirely, and consequently the physical breaks in stratigraphical succession excite little attention, except as interpreted by fossils. Their true significance is now very nearly, if not completely, overlooked. In the absence of fossils Irving was actually driven to the use of purely physical methods in dealing with the metamorphosed rocks, for any attempt to arrange the latter systematically, except upon faunal grounds, had been given up as useless. In other regions many writers before him had considered the phenomenon of marked discordant sedimentation as a structural feature and had actually gone so far as to regard unconformities as not only of regional but even of intercontinental extent. On the other hand, there were a very large number who believed that unconformities at best were only local phenomena and therefore of small importance in stratigraphy. It was Irving's particular mission to determine how far unconformities could be relied upon in a limited district, to point out clearly that in some cases they were of very wide, and in other cases of very limited extent, and in the geological classification of the non-fossiliferous rocks of a whole province, to propose a plan in which unconformities occupied a prominent place.

Since Irving's time, short though the period has been, there has sprung into existence a new department of geological inquiry, that not only reads later geological history in the geographic forms presented, but gives an entirely new insight into the real significance of unconformable relations between

the older rock masses. Of late the bringing in of the geographic methods as an aid to geologic interpretation finds a number of excellent expressions. but none happier nor more forceable than McGee's consideration of the Coastal plain deposits of the Atlantic slope.*

It is in the extension of Irving's theme as outlined, under the guidance of modern physiographic interpretation, that stratigraphy is believed to have found a rational and practical method of correlation and classification that, in its fundamental concepts, is entirely independent of the usual and almost universal paleontologic standard.

The criteria which have been employed at different times in the correlation of geological formations have been found to have widely varient values. But since all systematic arrangements of sedimentary deposits have for an ultimate end the delineation of the real superposition and relative ages of all strata, it is manifest that the scheme incorporating in its plan the actual sequence of the processes which have produced the events is the one which most nearly meets the requirements of a rational foundation for geological chronology. In proportion therefore as a classification is genetic is it of value as epitomizing the history of a region.

Since the recognition, at the beginning of the eighteenth century, of the geological significance of the bedded character of nearly every portion of that part of the lithosphere open to observation. the normal order of superposition of the layers has formed one of the chief problems of stratigraphy. In a single rock exposure it is ordinarily easy to determine which beds were laid down first and which last. But in making a comparison of two sections which are not visibly connected the case is not so simple, and when the two sections are widely separated the difficulty of paralleling them is correspondingly increased, and exact correlation is perhaps out of the question. It is the special province of geological correlation to establish a general chronological sequence of rock successions more or less widely separated. In the past the standards for this determination have been numerous. As they have come to be tested practically in the field they have been, one by one, abandoned entirely, passed over, or in lieu

*U. S. Geol. Surv., 12th Ann. Rept., pp. 245 520, 1891.

of something better have been used only provisionally, or with reservation. No single criterion has yet been proposed that answers the purpose successfully. Although some one of the various methods is commonly used as the principal one, the others are also followed at the same time. Hence, few correlation problems are now settled by a single standard alone.

The most important of the criteria which have been employed are: Mineral deposits contained, lithological similarity, organic contents, stratigraphic continuity, and discordant sedimentation. At one time or another each of these has had supremacy in geological work, and at the present time all of them are used to some extent, either directly or indirectly. At the Washington meeting of the International Congress of Geologists, Gilbert* arranged the common methods of correlation in the following way:

I. Physical, through
   1. Visible continuity.
   2. Lithological similarity.
   3. Similarity of lithological sequence.
   4. Unconformities.
   5. Simultaneous relations of diverse deposits to some physical event.
   6. Comparison of changes deposits have experienced from the action of geological processes supposed to be continuous.

II. Biotic, through
   7. Relative abundance of identical species.
   8. Relative abundance of allied or representative species.
   9. Comparisons of faunas with present life.
   10. Relations of faunas to climatic episodes.

For a long time general correlations have been almost universally carried on by the biotic methods. At present the factors of organic remains predominates over all others and is in fact the foundation of the commonly accepted system of geological synchrony. However, it is beginning to be recognized more and more clearly that organic remains are not the all-deciding factors in questions of correlation, that they are in reality accidental characters, and that when depended upon they must always be taken in connection with the physical features. In actual practice they are regarded as corrobora-

*Cong. géol. international. Compte Rendu, 5me Sess., 1891, pp. 151-155, 1893.

tive evidence after the main points have been determined by other means. For this reason chiefly it was set forth recently* that all the principal characters, stratigraphical, lithological and faunal, of every formation were so intimately interrelated in origin that the proper interpretation of any one of the three classes of phenomena presented should, under normal conditions, indicate the more salient features of the other two; but that, ordinarily, great difficulties were encountered in attempting to infer the entire geological history of a series of beds from a single group of facts. The larger part of the preserved records is in great measure inaccessible. Those portions which are open to investigation have been as yet only partially considered. For a long time to come the territory open to inspection will require constant study before the history can be made out even measurably complete. At the present time, therefore, it becomes absolutely necessary to carry on investigations, involving the historical sequence of geological events, along all three lines at once. Every fact is needed to throw light upon the general theme. If the problems were attacked in any of the three directions alone, without due regard for the evidence presented by the others, very different, and perhaps antagonistic conclusions might be reached, at least in the present state of knowledge. In the interpretation, then, of the geological history of a region, and in the erection of a classification of the formation in accordance with that interpretation, it is of prime importance to weigh carefully all the evidence set forth by the arrangement, composition and contained organic remains of the rock series as a whole, and of its several parts regarded as distinct units.

It has already been intimated that the basis of geological classification has been at various times in accordance with the very different standards, and that these have continually changed. In passing from one to another, however, the change has been gradual and not abrupt; for being bound so inseparably to the past it is well-nigh impossible for us to at once cast aside old ideas, even after we are fully convinced of their untrustworthiness. So, in clothing new conceptions in words, we unconsciously and unavoidably incorporate statements that are not only deceptive but which have their founda-

*Iowa Geol. Surv., vol. II, p. 62. 1893.

tions in error. Still, the expression of the new must be largely in terms of the old. In the discussion of our standards of comparison the old interpretations are naturally, yet unavoidably, incorporated, and more or less misunderstanding necessarily arises at first in the consideration of any new criterion. That every standard yet suggested for the determination of geological chronology has been inadequate when taken singly is conclusively shown by the daily practical tests that are made. A satisfactory solution to the problem does not appear to be offered by any system yet proposed. It has almost come to be the despair of investigators. A few years ago Whitney and Wadsworth* gave up all hope of unravelling pre-Cambrian geology without the use of fossils. Walcott,† after reviewing the methods of correlation in his essay on the Cambrian, concludes that "For the determination of synchrony, except in a limited area, there is little hope for satisfactory conclusions by any method yet devised." Gilbert‡ states that at present "the legitimate use of physical methods of correlation will necessarily be local * * * . The value of a biotic group for purposes of correlation depends (1) on the range of its species in time and space, and (2) on the extent to which its representatives are preserved." Hughes,§ in presenting the report of the British subcommittee on geological classification, clearly recognizes the fact that no one criterion is sufficient. "We must adopt the historical method * * * * . In geological history we must class together those results which naturally hang together, which belong more or less to one set of conditions as shown by the similarity of the inhabitants, as well as of the country occupied and of the structures which remain; that is of the fossils, the stratigraphy and petrology of the district. Our greater divisions must be based on the more complete changes and the smaller upon the minor fluctuations, which will be indicated only by the more sensitive and specially adapted forms of life, or by the more minute structural changes."

*Bull. Mus. Comp. Zool., vol. VII, p. 565, 1884.

†U. S. Geol. Sur., Bull. 81, p. 433, 1891.

‡Cong. géol. international, Compte Rendu, 5me Sess., 1891, p. 153, 1893.

§Cong. géol. international, Compte Rendu, 4me Sess., 1888, App. B, p. 9. 1891.

While it was widely recognized that the biotic criteria are not entirely adequate for purposes of general correlation, it remained for those working in terranes which were wholly devoid of organic remains to devise special methods for reaching the same end, methods which were entirely physical in character. The great object attained by the elaboration of these methods has been to point out that in the systematic arrangement of formations, satisfactory results are not only possible but that the relationships established are equally accurate and the methods equally as applicable practically as the most refined biotic methods yet used.

Since the classification of the Archæan (including Algonkian) was given up as impossible without the aid of fossils, Irving and Van Hise have formulated admirable methods of working, in which organic remains are left entirely out of consideration. McGee and his colleagues have, by purely physical methods, attacked the unfossiliferous deposits of the Coastal plain, and then have applied the same methods successfully to the fossiliferous terranes. Davis and others have rejuvinated the old methods of stratigraphical continuity and lithological similarity, by making possible a system of correlation by geographic forms, and broad areas are now being geologically mapped by this method alone. All of these methods are more or less complex and not simple, but they demonstrate that newer and more natural ways are rapidly replacing the older and more artificial ones, and that there is ample hope for devising physical means of correlation that are more in harmony with the real nature of the problems involved.

With the waning influence of the chief criterion which has long held sway in the accepted system of correlation the necessity gradually becomes manifest for a plan which is more in accord with the recent rapid progress and unparalled expansion of geological knowledge. Of the suggestions that have been offered of late years, for the establishment of a scheme of geological correlation independent of fossil evidence, the three just mentioned are especially prominent and are certainly destined to have wide utility and to be fruitful of grand results. By a combination, modification, and expansion of the central ideas of all these, together with the legitimate use of the cardinal principles involved, it is believed that a scheme

may be devised which will put geological correlation and systematic stratigraphy on a purely physical basis, that will be at once rational, practical and elastic. At the same time it will accord with the physical history of events, and will not inhibit the usage of all features of other plans so far as they are found to be trustworthy and of real service.

The primary object of geological correlation is the establishment of a general system of chronology. It finds expression in the classification adopted. In the development of every branch of natural knowledge one of the first considerations to receive attention is a systemization of the facts obtained. This orderly arrangement is one of the earliest prerequisites demanded of the branch in its attainment of scientific recognition; while its advancement is measured by the degree of taxonomic completeness and by the nature of the criteria regarded as critical. The bringing together of the various phenomena so that some sort of systematic relationship is made to exist among them all is the initial step in raising a particular department of knowledge to the dignity of a science. As progress is made a gradual evolution takes in the fundamental plan of grouping the facts. In the beginning, a classification, rude though it may be, is fashioned from the superficial features which are most striking at first glance. It is at a later stage modified to one in which similarity of the common characters, irrespective of natural relations, is taken into account. A vastly more advanced conception is classification based upon affinity, in which for similarity of features there is substituted similarity of plan. The final stage is the genetic, in which origin or causal relationship is the governing or predominant factor.

The classification of geological phenomena is no exception to the rule. In stratigraphy, as in other branches of geology, the various standards of comparison have given way, one after another, to other standards more expressive of the advancement of the science. But in the successive replacement of one set of criteria by another the abandoned groups are not found to be altogether wrong, and they continue to exert more or less influence, long after they are thought to be forgotten. In practice, then, the establishment of a rational system of geological chronology is not to be sought in the comparison of

any one set of external features, but rather in the direct causes which give rise to the phenomena. The final outcome is derived from a comparison of all groups of pertinent data in the physical history, taken *ensemble*.

A little consideration of the practical bearings of correlative inquiry shows that in a comparison of geological formations four aspects of the case are presented. The problem may be looked upon from a local, a provincial, a regional, or from a general standpoint. With the various methods of correlation which have been followed from time to time the universal practice has been to attempt to base the broader generalizations upon criteria that are, in reality, applicable only to limited areas. Hence, in passing from the more local to the more general, difficulties arise which become more and more formidable in direct proportion to the extension of the local scheme. Most of the methods that are applied and that are found to answer locally, fail when extended over larger districts. The real problem, then, is to find some means of solving the difficulties, for the latter or more general. When broadly applied most correlation criteria prove inadequate. The reasons are evident. As the specific distinctions are extended more and more widely they change and all are gradually replaced by different ones. It is manifest that in no case must the critical criteria deal with the intrinsic features as such, but with the causes giving rise to them. Moreover, the one great factor to be taken into account in every standard of comparison which has to do with correlation of strata is a definite basis to which the various minor, or local and provincial, successions can be referred. The fundamental conception is believed to grow out of a consideration of the nature of sedimentation itself. Natural phenomena rarely result from the action of single, simple laws. Each originates in many complex and intricate processes, some of which may be primary in character, but the majority of which are entirely secondary. For this reason the particular effects of the real causes are usually more or less completely obscured by conspicuous yet accidentally associated features. This is true in every department of science, as is clearly shown by the history and especially by the classifications that have been proposed during the different stages of development.

In seeking for a criterion that is fundamental in stratigraphy it is pertinent, at the outset, to inquire into the real nature of sedimentation, into the causes producing it, modifying it, and limiting it, into the forces called into action in subsequently obliterating their results, in fact into all of the primary processes involved and into the secondary processes which tend to obscure the actual workings of the real and fundamental laws. Only in this way can the main object in the establishment of an adequate and elastic system of geological correlation be attained and a ready interpretation of the history of terrestrial phenomena be made. Since from the strata of the globe must be deciphered the records of its history, the leading facts to be ever borne in mind and to be recognized to their fullest possible extent are that the elements of sedimentation are in large part the products of land decay, which form seaward-creeping fringes around the continental areas, and that the cessation of the action of the processes favorable is one of the prime factors in beginning each new cycle or great epoch in the physical history.

Since sedimentation goes on most actively along the borders of the great land masses of the globe, it is mainly a function of continental growth and decline. Its most important relation is with the shore-line, for the latter marks the boundary along which two very different processes are continually in action. On the one side degradation of the land is constantly carried on; on the other material is being continually deposited. To the rising or sinking of the land with reference to the sea, or to the continual advance or retreat of the shore-line are to be ascribed all the wide-spread changes in the character of the deposits thrown down in any particular place, and it is the variation in level chiefly that gives rise to the intricate and apparently lawless succession of lithologically different layers.

The immediate causes for the changes between the relations of the land and sea areas are to be sought in orogenic and epeirogenic movements. As the two kinds of movements cannot be readily separated practically, and as it is of small advantage to separate them theoretically, the results produced may be all regarded as arising from the one cause, from mountain-making forces. The greatest and most

abrupt modification in sedimentation, and consequently in lithological, stratigraphic, faunal, and in fact all characters, are those connected directly with diastatic change, producing depression of some land areas below sea level, and the uprising of other districts above the level at which they once stood, to form those great features of the earth's surface called mountains. Geological chronology, therefore, is believed to find a true and rational basis in those changes which primarily govern sedimentation and which are intimately connected with the genesis of mountain systems. It is proposed, therefore, to emphasize this factor as fundamental in the marking of the leading subdivisions of geological time and to define general stratigraphical succession in accordance with the cycles of orographic development, calling the classification or fundamental principle of correlation a systematic arrangement of mountains, or orotaxis.

By the term mountains, is meant not alone those geographic features which, at the present time, rise so majestically and conspicuously from the surface of the earth, but also all of those structures which have been in the past prominent characters in the surface relief, and which, geotectonically, are still mountains, though perhaps now completely base-leveled or long since buried beneath later sediments. With these old mountains the cycles of orographic development are properly regarded as extending from the time when the strata were compressed, through the periods when they were bowed up, then planed off nearly to sea-level. and submerged, perhaps, until new degradational products were deposited upon their upturned edges. The completed cycle of mountain-making is the measure of orotaxial chronology. The division planes cutting the geological column into systems, series, or smaller parts, are actually, as well as theoretically, the lines of unconformities and their representatives. In the case of the more extensive ones they do, no doubt, represent base-leveled surfaces or peneplains.

In all cases, great or small, the erosion plane and the period of degradation of the land has its equivalent in the sea in an accumulation of sediments. An ancient plane of unconformity, as it is now open to observation, may pass gradually into a great plain of sedimentation. In the grander unconformi-

ties in which the plain of discordant sedimentation represents essentially an old peneplain, the corresponding formation which is deposited in the sea area is usually a limestone. In fact most limestone formations may be looked upon as representing depositions during periods when the land adjoining was a graded surface or plain of faint relief lying but little above sea-level. This being the case, all unconformities have a much greater significance than has been heretofore suspected.

These surfaces of unconformity and their representative great units of sedimentation are the only absolute datum planes from which the measurement of formations can be estimated. Theoretically the formation is generally considered as a fixed and clearly defined unit; in practice it is found to be indefinite, ill-defined and incapable of definition in any but the vaguest terms. But from the datum plane of the unconformity a new sequence of strata begins, sharply and clearly set off from the formations below. Many, and perhaps most, of the sharp lines of division that once existed are now effaced over much of the present land surface, but in this respect the record is not more imperfect than any other. The longer a land area remains above sea-level the greater is the liability for the records of the earlier events to be destroyed. Over other districts in which sedimentation has gone on without material interruption during an even protracted orogenic movement, the line of delimitation between the various formations may not always be clearly descernible and might not, with existing data, be fully recognized, but with the detailed mapping of the country by the various official geological surveys the materials are either already at hand or soon will be, for sharply defining all the planes along which the lines of demarkation should be drawn. These lines, when once made out and when once properly considered, are as far-reaching and as universal in application as those of any classificatory system probably ever can be made. Where the sequence of events has been continuous, lines drawn through the very middle of a rock succession will not be perfectly arbitrary, but will be in accordance with the history more clearly recorded elsewhere.

While orogenic movements vary greatly both in intensity and extent they are probably as wide-reaching in their effects as any one regional force can be that is of use in geological correlation and chronology. They may be rarely or never continental, certainly not world-wide, in extent, but the different parts of each continent may be repeatedly affected so that a given region may be subjected to these influences from several centers of activity. The visible planes of unconformity which record these movements for each major region thus overlap and interlock in such a manner that from them all a moderately complete network may be constructed which will bind together in a compact whole and in proper chronological order all the minor parts. With the comparison of different continents the difficulties are greater but there are some lines which surely can be found that are common to both, just as in the case of the various provinces of a single continent.

In coming down to the lesser stratigraphical groups, as the series, stages and their subdivisions, the various subordinate or local criteria of correlation that are now in general use may be made serviceable in the defintion of the several members. The leading considerations are the geographical distribution, the lithological character, the physiographic expression, the stratigraphical delimitation, and the biological definition. In dwelling upon the main characteristics of each stratigraphical unit the whole physical history must be incorporated.

In general geological classification about the only practical attempt to use the orotaxial principle has been in the demarkation of the grand divisions or systems, and the events are commonly referred to as geological revolutions. The nearest approach to the actual application of the idea in any of its phases, has been by Irving* in his work on the pre-Cambrian crystallines of the northwest, in which unconformities are given great prominence, by McGee† in his investigations of the Coastal plain deposits of the middle Atlantic slope, in which similarity of origin, or homogeny, is the governing factor, and by Davis‡ and others in their physiographic work,

*U. S. Geol. Sur., 7th Ann. Rept., pp. 378, 1888.
†Am. Jour. Sci., (3), vol. XL, pp. 36-41, 1890.
‡Nat. Geog. Mag., vol. I, pp. 180-253, 1889.

in which periods of base-leveling are made the all-important features in the cycle of land degradation and the consequent sedimentation in adjoining seas.

If an east and west cross-section of the North American continent, as from Richmond to San Francisco, be considered, a diagrammatic representation may be made in which the geographic provinces are cut off by vertical lines and the geological systems by horizontal lines, the latter being separated approximately in proportion to the estimated time intervals. This stands for the continuous and uninterrupted geological history of the continent, and the stratigraphical succession from the earliest to the latest formations. In the proper places may be indicated the physical breaks in what would have otherwise been a continuous sequence. These lines of unconformity then extended laterally across as much territory as they approximately affected, and represent only the horizons, or the times at which they occur.

HUMAN RELICS IN THE DRIFT OF OHIO.*

By E. W. CLAYPOLE, Akron, O.

[Plate XI.]

That man existed in the old world during the later Ice age is a doctrine in anthropology regarding which little or no doubt can now be reasonably entertained. That he was present there during an interglacial era, if any such occurred, is scarcely less certain. And no small amount of evidence is already obtained which supports the opinion that man even preceded the ice in northern and western Europe. But on this side of the Atlantic the ice-sheet thus far has proved a barrier beyond which human footprints have not been found. Glacial man, and still more, interglacial man, is therefore here a shadowy, semi-mythical being of whose existence the anthropologist feels at best very uncertain.

It is true that not a few cases have been brought forward in which human relics have been found in such association with glacial deposits as to point strongly to the conclusion that both were of the same age. But in all these cases the deposits in question belong to the very latest stages of the

*Presented to Section H, A. A. A. S., Buffalo. 1896.

Glacial era and were the work of the retreating ice or even of the torrents that flowed from it after the area in which the remains were found had been left bare. Consequently, if every one of these cases was logically unassailable, and its evidence positively conclusive, the only inference would be that man was a denizen of North America during the final withdrawal of the ice, that he hung Esquimaux-like on its borders and followed it as it withdrew to the northward.

Of any earlier date than this, therefore, for man in North America we have no evidence whatever, and even this has been regarded with scepticism and its value denied by men of eminence in the field of archæology. Such scepticism is wise and justifiable so long as it can be logically maintained. So important a conclusion demands support much stronger than that which would amply establish many less momentous propositions. The first evidences of glacial man in Europe were received with an incredulity bordering on unreason by even the leaders of the geological thought of that day. Some part of this opposition was, it is true, due to a cause much more influential then than it is now—theological prejudice. Apart from this, however, a stubborn reluctance was manifested against the admission of a doctrine so new and so revolutionary as that of the great antiquity of man. But the slow accumulation of facts, which admitted no denial, had, at length, its inevitable effect and the doctrine is now accepted as the only rational conclusion from the data.

Here also certainty will come with time. If man lived in North America during the Ice age we shall find yearly more and more traces of that existence until the cumulative proof becomes irresistible. If he did not then exist the absence of such traces will become more and more obvious as the years pass by. A few doubtful instances may be explained away and leave no conviction. But many and repeated and constantly recurring examples, if well established, must, at length, pile up a mass of evidence that cannot be gainsaid.

Every archæologist is well acquainted with the cases that have been brought forward during the past few years tending to prove the presence of man in this country during the later part of the Ice age. Many also outside of the archæological ranks have become strongly interested in the question and

anxious to know whether glacial man was a reality or a myth. In so important a discussion it is right that every one who comes into possession of data that may have some bearing on the solution should contribute them to the general fund and without making any claim to the title of archæologist or anthropologist I therefore put on paper the following statements as made to myself and the results of enquiries so far as I have been able to follow them up.

Mr. Masterman's Narrative.

In the early part of the present summer (1896) an acquaintance of mine living in north-central Ohio called on me and showed me some implements which he had found during the past few years in the drift near the town, New London, at which he lived. Enquiring into the facts and examining the articles, I saw at once that, if no mistake had been made, the latter would be of considerable interest and possibly of no small value. I therefore noted down at once all that he could tell me, and after thinking over the data went to New London and spent a day on the ground, where Mr. Masterman was kind enough to drive me to the places of interest and thus enable me to obtain further useful and important particulars. Everything that I saw and heard confirmed the accuracy of his narrative and I returned convinced that, however we might explain the problem, the implements must have been found as described.

My next step was to obtain from Mr. Masterman a statement with his own signature of the exact circumstances in which the most important of these implements had been discovered. This statement is given below.

Statement regarding the finding of the grooved stone axe.

"I, Elmer E. Masterman, of New London, O., was engaged in the summer of 1886 in digging a well on the farm of E. Chapin, about two miles northeast of New London, and at the depth of twenty-two feet I found a stone implement, a photograph of which accompanies this statement.

"I placed it among my other curiosities, not from any thought of its possible interest or importance, but because of its lightness, which struck me as very singular. Its softness and stratified appearance also attracted my attention.

"It is a grooved stone axe, very much weathered.

"In digging the well I passed through the following strata:

"Eight feet of clay, very firm, yellow above and blue below, with small stones; under this were thirteen feet of silty material, very tough toward the bottom and requiring the use of a pickaxe for its removal. Interbedded in this were streaks of sand one or two inches thick. Last was about one foot of coarse gravel, yielding water. and containing some small subangular stones.

"Beneath all was a very tough, blue clay, impervious to water. I afterwards bored down 26 feet in the bottom of the well with a one-and-a half inch auger, but found only the clay throughout.

"I was alone in the well when I found the axe as there was not room for more than one to work there. No confirmatory testimony can therefore be given.

"I should further mention that nearer the surface, five feet down in the upper clay, I found a small arrow or spearpoint of white flint which accompanies the axe and is marked accordingly."

[Signed] ELMER E. MASTERMAN.

New London, O., July, 1896.

Mr. Masterman has also given me the following additional facts regarding his specimens. I quote from his letters:

"I have been collecting objects of various kinds within a radius of many miles for 21 years."

"I have taken pains to record any important or interesting specimen."

"I have many not found by myself. These were mostly given me. I have exchanged very little."

"I have not till lately paid any attention to the scientific value of any of my specimens."

"When engaged as an assistant at the World's Fair in 1893 I first learned of the discussion and controversies based on such implements, but even then I thought nothing of my own until my attention was drawn to this one by the Rev. W. Kepler, soon after which I called on Dr. Claypole," as already stated.

The above are the principal data connected with the finding of the implement. It is a grooved stone axe measuring four inches in length by two in breadth and one and a half in thickness. It weighs five and a half ounces.

Condition of the Axe.

The peculiar condition of the axe, to which reference has already been made, demands attention and adds of itself no slight confirmation to Mr. Masterman's narrative. It was made of the hard, banded. green slate so common in the drift of some parts of Ohio and which occurs in vast quantities

over many square miles of country in Canada, as for example near Sudbury. But it does not show the green color and close hard texture that usually characterize this mineral. It is deeply weathered and pitted so that on the surface it looks like a piece of ordinary "rotten-stone" being quite light in both senses of the word. Numerous small holes, resembling those made by worms in wood, are scattered over it and it altogether presents a perfectly unique appearance. I remarked this change to the finder and also the rarity of the material for this kind of implement. He said that he had never seen another made of this kind of stone. I have only one in my collection, a heavy weapon weighing several pounds and I have seen a few others, among them a very beautiful one in the Peabody Museum at Cambridge, but beyond all doubt it is a material not often employed, lacking as it does the high degree of toughness possessed by green-stone.

On my pointing out the importance of this decay of the stone as evidence and the need of ascertaining its extent Mr. Masterman at once gave me permission to saw it through. I did so with a common hack-saw in a few minutes without dulling the tool and to my surprise I found that the weathering had gone almost to the very middle, there remaining only a mere trace of the original stone, retaining the green color and hardness and affording conclusive evidence of its original condition. As additional confirming evidence the leached portion showed those concentric lines of color (limonite-stains) running parallel with the outlines that are so constantly present on oxydized pebbles and which furnish positive proof that the whole process has taken place since the stone received its present form. Whatever change therefore has taken place in this implement has come about since it was fashioned into an axe by its neolithic author. It is now so soft that it may be scratched with the finger-nail, and the "decay" is apparently due to the solution of some calcareous or other soluble ingredient originally contained in the slate.

The reader will see at once the importance of this matter and the strong confirmation which it lends to the story of its discovery inasmuch as it would not be possible to produce such an implement, unique as it apparently is of its kind, at least so far as the writer is aware. I will return to this point however hereafter.

Additional Testimony.

In addition to the confirmatory evidence afforded by the condition of the axe I may add that I have made enquiry of those who have known Mr. Masterman longer than I have done, and the uniform testimony is that he is a man of integrity whose word may be accepted as unimpeachable. In this opinion my own experience leads me fully to concur. I do not think any doubt is entertained on this point by any one who is entitled to come to a conclusion from personal knowledge. There only remains therefore to be considered the possibility of mistake or faulty memory and these seem quite excluded by the striking character of the stone and the peculiar circumstances attending its discovery.

But in order still further to strengthen this point and at the same time to anticipate a very probable objection, which has been urged with some force against previously published "finds" of this kind, I asked Mr. Masterman to give me the most exact and minute details that he could recall concerning the actual discovery and first sight of the axe. He replied as follows:

"I partly uncovered the axe when I shovelled the clay into the bucket in which it was raised to the surface. I came near striking it with the shovel but recognizing it I used my fingers and after a little effort removed it, *leaving an imprint of nearly one-half the thickness of the axe in the softish blue clay.* I placed it in my pocket and when I came out of the well I washed it with a vegetable brush to remove the clay which had got on it while I was trying to get it out." There is no room for faulty memory where so clear a recollection of the discovery remains. Nor does it seem possible that any mistake can exist regarding it.

Geology of New London.

The next topic demanding consideration is the nature of the strata in which the axe was found. New London is in the south-eastern corner of Huron Co. almost due N. N. W. from the point in Ashland Co., where the terminal moraine curves sharply to the southward in central Ohio. It is therefore about 40 miles back from the extreme limit of the ice-front and well within the drift area of the state. The country is flat, scarcely rolling, but it rises slightly to the south-

ward so that the drainage is in the opposite direction or toward lake Erie. About two miles to the south of the village a sharper rise begins and the surface rapidly reaches an elevation 200 feet higher forming a long, low, east-west ridge on the northern edge of the high land where lies the watershed of the state. Along this flows Buck creek from the northwestern portion of Ashland Co. until it finds a passage down the slope to the plain below on its way to the lake after joining the Vermillion river.

The district around New London is therefore a sloping hollow toward the north calculated to hold up the water coming from the retreating ice-sheet until some lower overflow-place was uncovered. A short-lived pond may therefore have existed in the county during part of the interval required for the recession of the ice from New London to the lake shore, but the high level 400 feet above lake Erie, forbids our belief in its long continuance.

The structure of the ground is in accord with this view. It consists of irregular strata of sand, and fine clay, sometimes a quicksand, overlying everywhere the tough blue boulder clay with small stones. These beds are not extensive or regular. In conversation with a well-driller who had had a large experience among them I learned that he had found a bed of sand perfectly dry at one place, to which by the way he had been guided by a water-witch with his hazel rod, and fifty feet from it, at a spot chosen by his own unaided intellect and at the same depth he had obtained abundance of water. Such variations were, he said, common over all the district.

This structure indicates plainly the deposits of the torrents of water and the still pools which characterize the flow from the front of a glacier in a flat country. In one place gravel is dropped, in another sand, and in a third even finer material such as clay may be accumulated. The indications at the spot where Mr. Chapin's well was dug point to an area of comparatively still water varied from time to time with slight currents which brought in the thin streaks of sand interlaminated with the clay. In other places especially to the westward gravel is much more abundant, the clay being often absent.

At the well nearly all the material passed through was clay becoming tougher and tougher downward and resembling the fine silt that settles from still water. The axe must have been deposited there when the thin gravel bed in which it was found was formed, as it lay directly upon the boulder-clay. If there is no other origin or date for the fine clay and streaks of sand that overlie it than that which assigns them to late glacial time then the tool must be set down to the same epoch and must be considered the work of glacial man.

There is no ground in the present instance for the objection that has been urged with much force in some similar cases— that the ground has been disturbed and that the implement is of later introduction. The well from which it came is situated in the wide plain already described. No river channel or quarry-face exists within a long distance. Buck creek, the nearest stream, is three miles to the south, and that excepted there is no break in the continuity of the surface and very little variation of level anywhere. The thin streaks of sand in the clay absolutely preclude any supposition that the ground had been previously disturbed, while the great depth (22 feet) and the nature of the soil passed through exclude all other theories that have been advanced in similar cases to account for the presence of implements in glacial gravels, such as falling into cracks, rotten root holes, etc.

The section as here given, moreover, is not dependent on memory, for on my pointing out the importance of accuracy and certainty in the evidence, Mr. Masterman offered to verify his statement by boring down alongside of the well. This he did nearly to the full depth and the only result was entirely to confirm his previous account.

Probable Cause of the Weathered Condition of the Axe.

I have already referred to the condition of the axe and this topic now calls for further notice. It was at first very puzzling, as such objects are not usually weathered to any appreciable extent even when lying on the surface. To find this one completely leached or oxydized throughout was therefore not a little surprising and I began to enquire into the circumstances in which it had been lying. The first point for investigation was the quality of the water and on enquiry I soon learned, as I had suspected, thas it was sulphureous. Further exami-

nation with the aid of Mr. Masterman's intimate knowledge of the district revealed the fact that all the wells and springs in a strip of country east of a certain line yielded water that was more or less of this nature. I visited several and observed this quality myself. Mr. Chapin's well, where the axe was found, lies in this tract, though here the taste and the odor are slight, perhaps from constant use. A spring at a short distance is a markedly sulphur spring. A line running approximately north and south through the school house limits the sulphur-water region, and to the west of this line chalybeate water prevails.

The cause of this difference lies, we may safely conclude, in the nature of the strata already referred to. The blue clay in or under which the implement was found is heavily charged with pyrites, a small lump of which is in my possession, brought up by Mr. Masterman during his recent drilling. The well known oxydation of this mineral furnishes a supply of sulphuric acid, and if the slate was, as is sometimes the case, at all calcareous, the lime would be removed by the action of this acid and the rotten and pitted condition of the implement produced.

On testing the water at the well no trace of free acid was detected, but a sulphate was abundantly present. This is what would be expected on the supposition made above. The sulphuric acid, produced by oxydation of the pyrites meeting with calcareous materials in the ground, would at once be converted into sulphate of lime and as such remain in the water, rendering it permanently hard.

In this way I would account for the peculiar and, in my experience, unique condition of the axe and at the same time I must point out how strong a confirmation it gives to Mr. Masterman's narrative. It would be, I think, absolutely impracticable in any way to produce such a condition artificially, and so deep and complete a weathering must be the effect, even naturally, of a very long time.

It must also be remembered that so abnormal and unusual a condition would be more likely to lead to suspicion and investigation than to ready acceptance and therefore to a greater probability of the discovery of fraud, had it been practiced.

During a recent visit to Cambridge, Prof. Putnam drew my attention to two or three implements in the Peabody Museum, which had been recalled to his mind by a sight of Mr. Masterman's axe. They are not grooved axes, but large celts made of shaly sandstone, which have obviously, like the axe, been weathered since they were shaped, and if an inference from their lightness is allowable they must be weathered throughout. Unfortunately their history is not known. They were found in Tennessee and on the surface, probably ploughed up. They are in precisely the same condition as are thousands of pebbles of the same material in the drift gravels of Ohio. Both are oxydized completely through.

No evidence can be drawn from these specimens in regard to the axe except in one point. The resemblance between them and the oxydized pebbles of the drift may mean that both have been equally exposed. And as the pebbles are assuredly of glacial date we can only on that view infer an equal age for the weapons.

Other Specimens.

So far I have confined my statement to the grooved stone axe in order that no confusion may arise on the subject. But Mr. Masterman has several other implements which should be at least mentioned. The argument for the axe must stand or fall on its merits. It is the strongest instance of all and yet may gain some additional value from the others.

Among these is a greenstone celt, found five feet deep in the clay in digging a county ditch in 1889. This is within the sulphur-water region and shows slight traces of solvent action, the feldspathic (albitic) portion being decomposed to a small depth. Other celts of greenstone from different places where this water does not prevail show no traces of similar action. The finder of this was Mr. E. E. Masterman.

Another specimen is a grooved axe of greenstone found in 1882 seven feet deep in the gravel. This also shows traces of chemical action and lay in the region of the sulphur water. It was found by E. Morris and given to Mr. Masterman.

A third is a very rough and unfinished celt of slate showing a chipped surface over the greater part and traces of grinding only in a few places. It is, however, unquestionably of human make, and not lying in the region of the sulphur water shows

none of the changes so conspicuous on the axe. It is marked 1895, "13 feet deep in the gravel," and was found by Mr. Masterman.

A fourth is a very large specimen of an unusual pattern and probably unfinished. It is shovel-shaped, eight inches from side to side and five inches deep, roughly chipped all around the edge, composed of veined slate, conchoidal in fracture, with two natural faces which show a little more trace of oxydation than do the chipped edges. It bears the record "July 14, 1884, 5 feet in gravel," and was found by D. White in digging a ditch and given to Mr. Masterman.

A fifth specimen is a well formed but thick spearhead, made of red flint, about 3½ inches long by 1¼ inch wide and chipped all over both faces. It was found by Mr. Masterman himself at a depth of seven feet while digging a well.

Whether or not, in the opinion of archæologists, the case is strengthened by the addition of these minor "finds" must be left to individual judgments to decide. It would not be just to present it without at the least mentioning them.

There are in Mr. Masterman's possession a few other implements, met with in similar circumstances but not being found at any greater depth than those just mentioned no purpose would be served by lengthening out this paper with their details. They all lie in the same set of glacial gravels and there is no probability that they, any more than the axe, have been subsequently introduced. But it is not possible now to investigate these minor cases.

Conclusion.

It remains only to consider some of the difficulties and objections that will doubtless occur to archæologists on consideration of the narrative above given. It must of course be subjected to the closest scrutiny and the severest criticism in order that its exact value may be ascertained.

It will not be necessary to repeat the remarks made in the course of this article in regard to some anticipated objections, such as accidental intrusion, slip, talus-inclusion and some others familiar to the student. I will only notice a few somewhat obvious difficulties.

1. It may be asked why these relics should be so comparatively numerous near New London when they are not found

elsewhere save in single or sporadic instances? To this question there are two possible answers. In the first place, granting that man resided in Ohio in late glacial days, there were doubtless some spots more frequented than others just as we find certain spots now, such as the neighborhood of springs and streams, camping grounds, etc., in which flint and other weapons may be gathered abundantly whereas over the rest of the state they are met with far less frequently. Secondly, there are very few places where any one has taken the trouble to look for and save such things and record them when they were found. It is impossible to know how many specimens may even now be, as these were for years, in the hands of collectors who fail to realize the important evidence which they are able to afford on the subject of early man.

2. A second objection that will be felt and doubtless pressed by some anthropologists may be drawn from the nature of the weapons. They are neolithic in pattern whereas an opinion is somewhat prevalent that implements found in such circumstances should be of palæolithic type; at least such a conclusion may fairly be drawn from much that has been written on the subject. But this opinion can scarcely be well founded. In Europe where later glacial, interglacial, and possibly preglacial relics of man are more or less recognized the first mentioned are not palæolithic. This character belongs strictly to those of the second and third eras. All such are palæolithic and betray by their pattern an ancient origin. We should anticipate similar results here and the facts above given are in accord with this view. These implements bear every trace of comparatively recent date and they occur mixed in the clay and gravel deposits of the melting ice-sheet. The evidence of their entombment proves that they belong to the closing years of the glacial era—at the least their inclusion in their present matrix is of that date. In Europe neolithic man followed the Ice age, perhaps after a certain interval, perhaps immediately, and a broad and deep gulf separates him from his palæolithic ancestors.

Secondly, this late date corresponds well with the results of investigation into the time of the disappearance of the ice. Most of the data attainable will not allow more than about 10,000 years as the interval that has elapsed between that epoch and the present time.

Every one familiar with European anthropology will demand a longer era than 10,000 years, counting back from the present day, for the existence of neolithic man on that continent. But when we reflect that neolithic culture was almost certainly introduced into America from Europe and must therefore be younger here than there we may possibly be satisfied with that amount of time for the American neolithic dynasty.

I may add that it is at present far from certain that palæolithic man ever reached this continent at all though the doubt rests at present on merely negative evidence.

3. It will of course be urged that this conclusion which seems legitimately deducible from the narrative here given, if accepted, rests at bottom on the testimony of one man. In a measure this is true though I have taken occasion to point out how strongly circumstantial evidence supports this testimony in a way that seems to render scepticism quite unreasonable. Beyond that the only reply that can be made is that almost all similar cases *must* in like manner rest on the testimony of some one individual. The way in which specimens occur precludes the possibility in most cases of securing any other testimony and even if it should be the good fortune of a geologist to come on such a relic himself the rest of the world, if it accepts the "find" at all, must accept it on his testimony alone. It is in the highest degree improbable that such relics will ever be discovered and disinterred in the presence of the geological and anthropological societies of the country. By cumulative evidence derived from the multiplication of carefully investigated cases must the question of man's antiquity in North America be answered.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Text-Book of Palæontology. By KARL A. VON ZITTEL Translated and edited by CHARLES R. EASTMAN PH. D.. Vol. I, Part 1, with 593 wood cuts, pp. 352. A mere translation, from German into English, of the great text-book of professor Zittel would have been no small task: and such a work would at any time have met a hearty welcome at the hands of American students of palæontology. Dr. Eastman, however, has undertaken more than a translation. With the consent and co-op-

eration of the author and "in collaboration with numerous specialists" most of whom are Americans, he has undertaken to bring the text-book into harmony with the latest knowledge of specialists in all departments of the many-sided science of palæontology.

Since the publication of the German edition of the text-book in 1880 palæontology in common with all other sciences has made great progress. Brady's report on Foraminifera has appeared; Nicholson has completed his monograph on the stromatoporoids; our knowledge of the morphology and taxonomy of crinoids has been enlarged by the labors of Carpenter and Bather, and by the epoch-making work of Wachsmuth and Springer; the publication of the results of investigations on the Echinoidea by Duncan, Clark and others, has made it possible to recast the classification of that group of organisms; Ulrich has practically created the paleontology of the Bryozoa; and Beecher, Schubert, Hall and Clark have made it necessary to discard to a large extent the old taxonomic divisions of the Brachiopoda.

The part before us ends practically with the Brachiopoda. There are a few pages—344 to 352 inclusive—devoted to a general discussion of the Mollusca and of the class Pelecypoda, but the whole subject of classification of the Mollusca is reserved for the second part of volume I.

The difference in the treatment of the several groups of fossil animals in the translation and revision, as compared with the original edition, becomes apparent at the very beginning of the volume. The classification of the Foraminifera has been completely recast. In place of the sub-orders Imperforata and Perforata of Carpenter, the classification follows Schwager in dividing the Foraminifera into the four groups Chitinosa, Agglutinantia, Porcellanea, and Vitro-calcarea. The distribution of the genera in families follows somewhat closely the arrangement adopted by Brady. The much discussed Eozoon is relegated to the category of "mineral segregations."

In the group of sponges the departure from the arrangement of genera and families in the original work is scarcely less marked than in the Foraminifera. The studies of Hinde and Ulrich, but more than all the classic work of the author, since 1880, have placed the knowledge of the structure and relationships of fossil sponges upon a more satisfactory basis. None of the previously published systems of classification, however, has been followed in all details in the present work.

Notwithstanding all that has been written on the systematic relations of the Paleozoic corals, the classification of this assemblage of organisms still remains in a very unsatisfactory condition. The old group of tabulate corals is probably in worse state than any of the rest. It has been broken up by various authors and distributed among different divisions of the Alcyonaria, Hexacoralla and the Bryozoa. In the present work the separated members of the group are re-assembled and treated in an appendix to the Hexacoralla. Favosites, Halysites, Syringopora, Aulopora and even Chætetes and Fistulipora, here stand once more in their old friendly relations. This statement, however, requires some modification. It is true only so far as relates to the por-

tion of the work devoted to corals; for when we come to the Bryozoa, a subject which has been largrly rewritten by Ulrich, we find the fistuliporoids and monticuliporoids separated from their fellows of the old Tabulata and from each other, and ranged under different ordinal divisions of this interesting class of Molluscoidea. No better disposition of Heliolites and Plasmopora is proposed than to leave them with the recent Heliopora under Alcyonaria.

With some slight modifications, both in taxonomy and the terminology of the structural elements, the crinoids have been revised in accordance with the latest published deductions of Carpenter, Bather, and Wachsmuth and Springer. In no group of organisms has a knowledge of the significance and homologies of structural elements progressed more rapidly in recent years than among crinoids. In no group have changes of views among specialists followed each other in such quick succession. It may not be safe to say that further progress, involving future modifications in taxonomy, is improbable; but it may be affirmed that the scheme of classification presented by the work before us is up to date, and represents the fullest, latest, best information on the subject.

The other classes of the Echinodermata may not have fared as well as the Crinoidea, but all are treated fully and in accordance with the best knowledge at hand. Billings' genus Glyptocystites seems, however, a little out of place in the Caryocrinidae, and the American Devonian genus of the Cystoidea, Strobilocystites, might have had a place in a text-book that will be largely used on this side of the Atlantic.

The Bryozoa have been revised by Ulrich as already noted; and that the classification of the Brachiopoda is in accord with the latest determinations of structural affinities in this important group is attested by the fact that the chapter on the subject was revised and largely re-written by Schuchert. The conclusions of Hall and Clark in *Paleontology of New York, Vol. VIII*, are somewhat closely followed.

The work undertaken by Dr. Eastman and his collaborators is one of great magnitude, and if the remaining portions of the text-book reflect the latest knowledge of the several parts of the science as does the one already issued, paleontologists, not only in English speaking countries, but throughout the world, will be placed under lasting obligations.

S. C.

On the Vertebral Column, Fins, and Ventral Armoring of Dinichthys. By BASHFORD DEAN (Trans. N. Y. Acad. Sci., vol. xv, pp. 157-163, pl. vii, viii, 1896.) By means of this paper, which represents the author's study of a unique specimen of *Dinichthys* in the collection of Dr. William Clark, our knowledge of this interesting genus of fossil fishes is greatly increased. The vertebral axis and supports for the dorsal and ventral fins are here described for the first time, and important relations are pointed out between them and the conditions existing in *Coccosteus*. It is noted that the dorsal fin occupies the same relative position in both genera, but it is "smaller and more delicate in *Dinichthys*, the latter character being directly opposed to what might have

been inferred on *a priori* grounds." To the reviewer, this fact appears confirmatory of the suggestion recently advanced that the swimming powers of *Dinichthys* were centered principally in the hinder part of the trunk and tail. and were in direct relation with the posterior process of the dorsal shield, a process which finds its most complete development in this genus.

Of great interest is the author's description of the ventral armor, and his comparison of it with other forms. Wright's able interpretation of the system is supported in the main, and is at the same time completed by the discovery of an undoubted ventro-median plate. If Dr. Dean's view is correct that this element is single and undivided, the species presents a marked variation from the normal condition in the dinichthyids, and in the *Arthrodira* generally; and yet, such a variation is readily explicable, when we consider the loose connection between the ventrals and their great tenuity, as a device for strengthening an otherwise fragile plastron. Nevertheless it must be observed that the evidence is not entirely decisive on this point, owing to the extremely weathered condition of the anterior portion of the ventro-median. What Dr. Dean considers to be the homologue of an antero-ventro-median may be in reality all that is left of that very element itself, which had become displaced downward so as to overlie the ventro-median proper, and afterwards had suffered almost total obliteration. In any case we know that two elements are potentially present, an anterior and a posterior, but whether the relation between them was one of fusion or of suture appears to be indeterminate from the specimen itself. It is unfortunate, too, that the conditions of overlap among the several plates are not clearly decipherable from the present specimen, nor are they indicated in Prof. von Koenen's recent description of *D. minor* (?). The precise relations of the elements constituting the ventral armoring have yet to be ascertained from a specimen preserved *in situ*, such a one, for instance, as was briefly noticed in the last number of the GEOLOGIST, (p. 222). This much, however, is already certain: namely that the ventral plates of *Dinichthys* are subject to greater variation, even within specific limits, than all the others of the derm covering. One class of variations may be alluded to here, which is known to affect different individuals of one and the same species, and that is the relative length of the anterior ventro-laterals as compared with the posterior pair. In one series, (A), the former are longer than the latter, and the total length of the plastron is greater than in the corresponding series, (B), where the reverse condition obtains. Augmentation in length was only possible in a posterior direction, the anterior boundary being fixed; hence the first series must have had the abdomen protected by a plated covering over a greater area than in the second series. Although a matter of pure conjecture, it is not altogether unreasonable to suppose that these differences were correlated with sex. C. R. E.

Fifteenth Annual Report of the United States Geological Survey to the Secretary of the Interior, 1893-'94. By J. W. POWELL, Director. (Pages xiv, 755; with 48 plates, and 29 figures in the text: Washington,

1895.) The appropriations for the fiscal year here reported were $209,-200 for topographic work; $55,000 for engraving and printing maps; $83,-700 for geologic work; $14,000 for paleontologic work; $8,000 for chemical work; and $89,740 for other purposes,—making a total of $459,640. Besides this amount, an additional sum of $35,000 was allotted for expenditure by the public printer in the publications of the Survey. The strictly geologic portion of the Survey was carried forward by twenty-five chiefs of divisions and heads of independent parties, whose individual administrative reports follow that of the director.

On June 30, 1894, ending that fiscal year, the directorship was resigned by major Powell, and Mr. C. D. Walcott became his successor. In bidding farewell to his collaborators, Powell says: "Under different organizations I have had charge of the work for twenty-five years, In the beginning it was largely exploratory, but gradually, as the Survey expanded, it became more and more administrative, affording less time for research. The changes made in the personnel of the Survey have not been great, but steadily the scientific corps has been enlarged. . . . In this severance of our relations, made necessary by painful disability, I can not refrain from an expression of profound gratitude for the loyal and loving aid which they have given me, ever working together with zeal and wisdom to add to the sum of human knowledge. The roster of these honored men is found in ten-score volumes of contributions to knowledge, and fifty-score maps familiar to the scholars of the world. . . . May the achievements of the past be crowned with the higher achievements of the future!"

This report is accompanied by five special papers or memoirs on branches of the field work and investigations of the Survey, which are noticed in the following pages. W. U.

Preliminary report on the Geology of the Common Roads of the United States. By NATHANIEL SOUTHGATE SHALER. (Fifteenth Annual Report, U. S. Geological Survey, pp. 255–306.) An important indirect benefit arising from the invention of the bicycle and its extensive use, especially in the large cities and their vicinity, is a demand for improved road construction. In this paper, Prof. Shaler gives an outline of the history of American roads, and treats of the methods of using stone in road building, the relative value of road stones, and their distribution or sources of supply in the United States. Basalt is found to be much the best material for macadam; but, in the great interior region of the Mississippi basin and Laurentian lakes, limestones, although relatively poor road material, are most used because of their accessibility. W. U.

The Potomac Formation. By LESTER F. WARD. (Fifteenth U. S. Geol. Report, pp. 307–397; with three plates, and four figures in the text.) Six members, named, in their ascending order, the James River, Rappahannock, Mount Vernon, Acquia Creek, Iron Ore, and Albirupean series, make up the Potomac formation. The first two members are classed together, in view of the affinities of their fossil plants, as the Basal Potomac; these and the next two series are united under the term Older

Potomac; and the two higher members are called the Newer Potomac. "Upon the whole," writes Prof. Ward, "I am disposed to consider the Potomac formation as a Cretaceous deposit, but as occupying nearly the whole interval from the close of the Jurassic to the base of the Upper Cretaceous, as that is commonly understood. The complete distribution of its fossil plants will, I doubt not, justify this conclusion."

It is now ascertained, as made known quite fully in this memoir, that the Raritan and Amboy clays of New Jersey belong to the same epoch as the Newer Potomac, being somewhat earlier than the Dakota formation.

The total Potomac flora comprises 737 distinct forms, consisting chiefly of ferns, cycads, conifers, and dicotyledons, the last named class being represented by 92 genera and 330 species. W. U.

Sketch of the Geology of the San Francisco Peninsula. By ANDREW C. LAWSON. (Fifteenth U. S. Geol. Report, pp. 399-476, with eight plates, and three figures in the text.) The seven terranes of this area, in ascending order, are (1) crystalline limestone, of unknown age; (2) the Montara granite, intrusive in the preceding; (3) the Franciscan series, of Mesozoic age, resting on the eroded Montara granite, an assemblage of sedimentary and volcanic rocks of great thickness, with which are associated various basic intrusives, notably peridotite serpentines; (4) a light-colored, cavernous-weathering sandstone, supposed doubtfully to be of Tejon age; (5) the Monterey series, of Miocene age, chiefly white, siliceous shale, resting on the last; (6) the Merced series, of Pliocene age, a thick volume of sediments, with one stratum of volcanic ash, deposited after the erosion of the Monterey terrane; and (7) the terrace formations, of Pleistocene and Recent age, deposited after the disturbance and partial denudation of the Merced series. Among these, the Montara granite, the Franciscan series, and the Merced series, are the dominant features in the geology of the peninsula.

The development of the present physiography is found, by Dr. Lawson's investigations, to have depended on the following principal geological factors: (1) the formation, one after the other, of two similarly tilted fault blocks sloping to the northeast and precipitous to the southwest; (2) the presence of subordinate faults and folds in these fault blocks; (3) the variously resistant character of the formations constituting these blocks; (4) the existence of the earlier and more northern block above baselevel and the consequent inauguration of its sculpture before the second block was thrown up; (5) ensuing subsidence of the region and formation of the second fault block; (6) the emergence in unison of these two great block forms from the Pacific; (7) their sculpture as conditioned by (*a*) their relation to baselevel at various stages of the uplift, (*b*) their petrographic heterogeneity, and (*c*) their structural complexity; (8) the formation, as an episode in the uplift, of marine terrace deposits on the lower slopes of the fault blocks; (9) the sculpture of these terraces; (10) associated accumulation of dunes; (11) a recent subsidence; (12) the formation of the present tidal flats, deltas, etc.; and (13) modern shore erosion. W. U.

Preliminary Report on the Marquette Iron-bearing District of Michigan. By CHARLES RICHARD VANHISE and WILLIAM SHIRLEY BAYLEY. *With a chapter on the Republic Trough.* by HENRY LLOYD SMITH. (Fifteenth U. S. Geol. Report, pp. 477-650. with fourteen plates and twelve figures in the text.) The general geological map of the district here described, on the scale of a mile to an inch, with contour lines for each 50 feet, covers an extent of thirty-eight miles from the vicinity of Marquette west by Negaunee and Ishpeming to Michigamme, with a width of nine miles, excepting that on the south it reaches three miles farther in the valley of the Michigamme river to Republic. The basement complex of Archean rocks on the north comprises the Mona schists, Kitchi schists, gneissoid granites, hornblende-syenite, dike rocks, and peridotite; while on the south it is chiefly granitic, with the Palmer gneiss and dike rocks.

The stratified Algonkian rocks are divided in the Lower and Upper Marquette series, which are regarded as equivalent with the original Huronian north of lake Huron. The lower series includes, in ascending order, the Mesnard quartzite, Kona dolomite, Wewe slate, Ajibik quartzite, Siamo slate, and the Negaunee formation of iron-bearing slates and schists, the last named formation being about 1,000 feet thick. In the Upper Marquette series, following the same ascending order, are the Ishpeming quartzite, the Bijiki schist, and the Michigamme and Clarksburg formations. The present thickness of each of the two Marquette series is about 5,000 feet, or less; and they are folded and fractured in a very complex manner, with much metamorphism.

Concerning the minute fracture and deformation of these series of rocks, the authors remark: "A microscopical study shows that not a cubic inch of material has escaped dynamic action. Almost every original grain of fair size gives evidence of interior movement. The rocks have been kneaded throughout. While as a further consequence of dynamic action there has been local faulting at various places, with two or three exceptions no important faults have been observed in the district...... Had the rocks which are now exposed not been deeply covered, it is hardly possible that the complicated folding......could have occurred without complicated faulting."

As in the Penokee district of Wisconsin and the Vermilion iron range of Minnesota, the ore deposits seem to have been formed chiefly after the regional folding took place. Surface waters, bearing organic acids and percolating down through the iron-bearing rocks, received their iron into solution, and deposited it in the rich ore bodies where they encountered alkaline and silica-removing waters furnished by the alteration of the adjoining igneous rocks. W. U.

The Origin and Relations of Central Maryland Granites. By CHARLES ROLLIN KEYES. *With an Introduction on the General Relations of the Granitic Rocks in the Middle Atlantic Piedmont Plateau,* by GEORGE HUNTINGTON WILLIAMS. (Fifteenth U. S. Geol. Report, pp. 651-740, with 22 plates, and nine figures in the text.) In the introduc-

tory paper, by the late Prof. Williams, he states his conclusion that the eastern part of the United States has no truly plutonic rocks of demonstrably younger age than the end of the Paleozoic era, when the Appalachian mountain belt was uplifted and folded; but they are found in abundance of all ages down to that time. From his studies in Maryland, as set forth here in detail, Williams was led to believe that pegmatites, in some cases produced by aqueous segregation but in other cases by igneous intrusion, and quite similar in appearance, occur side by side.

Summarizing the investigations of the granitic rocks of eastern central Maryland, Dr. Keyes finds that some of the granites are eruptive: that both epidote and allanite occur in the eruptive granites as original constituents; that muscovite is a primary mineral in the very acid granites of Guilford, Md.; and that certain gneisses are derived from granites, their schistosity being a result of orogenic movements with shearing and partial recrystallization. W. U.

Reports on Areal Geology, Sheets 1-4. (Missouri Geological Survey, vol. IX, 420 pp., 4 maps, 25 plates, 51 figures, 1892-1896.) The general plan of publication adopted by the state geologist, Dr. C. R. Keyes, is a single series of royal octavo volumes. The plan of the work is of a twofold nature, embraced under what is called subject work and areal work. Eight volumes, embracing some of the results of the former, have already been published; the present volume is the first of the areal reports. As stated in the list of the publications of the Survey, the areal (or sheet) reports are issued in three different editions to meet the demands of different classes of people, in order to supply the necessary wants and at the same time not to compel the issuing of an unnecessarily large number of each. The editions of the areal reports are as follows:

First. Several reports are bound together, in cloth, with folio topographic and geologic maps on thin bond paper and folded, the whole forming a volume uniform in size and style with the regular series of the final large octavo reports of the Missouri Survey. The first group of these areal reports form volume IX of the regular series, and consists of four parts, or reports on (1) Higginsville sheet, (2) Bevier sheet, (3) Iron Mountain sheet, and (4) Mine la Motte sheet.

Second. Text same as in the first, bound in cloth as volume IX of the regular series, but the folio maps are unfolded, printed on heavy cardboard, and each enclosed in heavy paper covers.

Third. Text of each report is bound as a separate brochure, with folio maps on thin paper and folded.

The first of the sheet reports appeared in pamphlet form several years ago and two others more recently. The necessity of a dual arrangement of work in completing a thorough geological survey is obvious. On account of the magnitude of the work the investigations must necessarily extend over a period of several years. The means usually provided are far too inadequate to extend the detailed work over a whole state in a single year, and consequently in the beginning of the work some areas

must be taken up first and finished, before others can be inquired into and mapped in detail. At the same time the work on various topics may go on over the whole region and the results of the investigations on the various deposits published and given to the public long before all the work of all the counties or districts is done. By careful planning beforehand there arises no duplication of work nor publication, and the reports meet the wants of two large classes of people—the one seeking information of a general character for the state as a whole, together with detailed information concerning the particular adaptabilities, accessibility, etc., of the different mineral substances; the other seeking detailed information regarding particular localities. The strictly scientific aspects are treated in the same manner. U. S. G.

A Preliminary Report upon the Florida Parishes of East Louisiana and the Bluff, Prairie and Hill Lands of Southwest Louisiana. By W. W. CLENDENIN, Geologist, April, 1896. pp. 161–256. One must needs look everywhere now for information if one would remain posted on geological literature. Time was once when a few periodicals or a few state surveys published all the geological papers there were. Nowadays we have general periodicals and special ones: scientific society proceedings by the score: bulletins of museums; accounts of private or public explorations; state and national surveys. The latest place in which one must look is in the file of publications of the Agricultural Experiment stations, that have sprung up like mushrooms in the last few years. Fostered by the general government and with a guaranteed subsidy of $20,000 per annum, to be gradually increased until it reaches $25,000, poor indeed, is the State that cannot afford to set apart some portion of its domain as an experimental farm. Some of these stations have assumed work of a sort that seems, at first sight, outside of their legitimate sphere. Although in the cases where it would not be otherwise done, they are justified in inaugurating it. Louisiana, for example, has set on foot a geological reconnoissance of which three parts have been published. The first two, under the direction of Otto Lerch, were published in 1892 and 1893,* the third is the one at present under notice.

The "Florida Parishes" belong to that part of Louisiana that was not included in the Louisiana purchase, but was acquired later by "occupation" by the Americans. The district reported on lies south of the 31st parallel and between the Pearl and the Mississippi rivers. Southwestern Louisiana, reported upon, is to the west of the Atchafalaya river to the Sabine, "south of the latitude of Alexandria." Naturally in a survey like this, agricultural rather than geological, more attention is given to the soils than to the rocks making them or to the terranes to which they belong. While at the same time it is not an easy matter to trace the geological history where natural sections are few and where the alluvial covering is so extensive. After describing briefly the topographic features of the country, it is noted that the Columbia and the LaFayette formations are those chiefly occurring. Soils and economic

*A Preliminary report upon the Hills of Louisiana, north of the Vicksburg, Shreveport and Pacific railroad. Parts I and II, pp. 160.

products (mineral and vegetable), are dealt with mainly, but in the last section a number of well sections and a few others are found.

Tacked on to the geological report is a botanical one, in which Prof. Dodson gives lists of "Trees" (evergreens), "Oaks," "Trees and shrubs of minor importance," etc. These lists do not, of course, pretend to be complete. They show, unfortunately, quite careless proof-reading. O frequently masquerades as *a* and *vice versa*, and *u* is quite often represented by *n*. Some of the mistakes are quite inexcusable.

As very little has heretofore been written regarding Louisiana geology one must needs be grateful for what is now accorded. J. F. J.

CORRESPONDENCE.

PROF. LESLEY'S FINAL REPORT. This "final summary" of the geology of Pennsylvania* has, after some years, been completed, and it is a fitting conclusion of the second geological survey of Pennsylvania. It is largely the work of the veteran geologist, J. P. Lesley, and the world owes him a debt of gratitude. The citizens of the Keystone state, too, may well be proud of the monument he has reared for them. While there is no State that has not at some time or other had a geological survey, there are few that can boast of any summary of the knowledge gained by the years of research. The details of a survey are of vast importance to the scientific world, but it is the results that a majority of persons desire. Too often these results are so hidden away among the mass of details that they are totally obscured, or are, at best, inaccessible. But in these volumes we have an epitome of many thousands of printed pages, facts garnered from many volumes and arranged in great part by a master hand. For, besides representing to the general public the work they have paid for for so many years, the volumes give to the scientific world the opinions of a geologist whom all must honor, on many subjects that are discussed in the geological world; and above all, it is written in a clear and charming style, far different from the too often dry method of the ordinary geological report. It is unfortunate that Prof. Lesley could not have written the whole, for a large portion of the last volumes is by other hands, and lacks the animated method of the first 1,800 pages.

There are but few problems that have confronted geologists upon which Prof. Lesley does not touch, and they are discussed in plain "Saxon English," the author preferring "before and after or before and behind to anterior and posterior, and overlaid and underlaid to superimposed and subjacent." (p. IV.)

The first volume opens with several chapters on general geology in which are discussed geological time, dimensions, sections, etc. His re-

*A SUMMARY DESCRIPTION OF THE GEOLOGY OF PENNSYLVANIA. Harrisburg, 1892–95, 3 vols. in 4, with index and atlas, pp. XIX, 2638, pl. 611.

marks in regard to the first, (geological time) are very apt, and we quote them to give an idea of the writer's style. The ordinary ideas of time cannot be applied in geology because they so far exceed all ordinary modes of measurement. Geology deals with such vast time epochs that for all practical purposes time is infinite. "Science, especially the science of geology, dispenses time as the commonest drug in the market of the universe."

"The idea of precise time is the product of the routine of civilized human existence. It is unknown in the vegetable and animal worlds; it is disregarded by nomadic races. The idea took root when the home was organized by women and meals were cooked at fixed hours of the day. It became confirmed when superstition organized priestcraft, and religious ceremonies demanded a calendar. The moon was the first clock. . . . Even now, with all the chronometers of Christendom, it is still a fact that nineteen-twentieths of the human race have never seen a clock, and have no practical need of one." (p. 7.)

Several examples are given of the methods of estimating geological time, as from the rate of deposit or the rate of erosion. He does not believe, however, in the elaborate methods adopted by some to estimate the age of the earth, although erosion can be used as a rough means of estimation. So that basing the rate of erosion in the Juniata valley at one foot in 1,500 years, and calculating the average elevation of the country originally at 9,000 feet, some 13,560,000 years would have to elapse to bring the country to its present level.

Prof. Lesley is not a believer in the theory of the permanence of continents and oceanic basins, remarking (p. 37): "The two thoughts which are here fundamental to the knowledge of our Pennsylvanian geology are these: (1) that what was the continental area of crystalline rocks became by the downward movements of the earth's crust an Appalachian sea basin of unknown depth, and was in the course of the Cambrian, Silurian, Devonian and Carboniferous ages so completely filled up as to become at best a great marsh or archipelago of marshes, bearing the vegetation of the coal; and (2) that this whole area was then lifted high into the air; that a corresponding contemporaneous movement established the Atlantic ocean or parts of it, as the thrust which elevated the Appalachians came from that direction: and that submergence of other lands of the world must have been occasioned by the general rise of the sea level."

Dr. Walcott has expressed his belief that the sediments of the Lower Cambrian were deposited in troughs extending northeast and southwest along a continental mass lying to the westward; but Prof. Lesley believes the sediments of the whole Paleozoic period, from the Cambrian to the Carboniferous were derived from a continental mass lying to the eastward, and that when the Mesozoic began "a genuine cataclysm" produced the continental area of the United States. For he says: "The overthrust faults are of themselves alone sufficient to prove it. A belt of parallel mountains, as high as any that now exist in South America or Asia, rose into the air along a line extending from the St. Lawrence

to the gulf of Mexico, passing through Pennsylvania. The whole Appalachian sea was drained off and became dry land, a continental area of coal measures, much of which has since been carried away, but much still remains, constituting the extensive coal fields of the present time. The whole rain water drainage was reversed. The Palæozoic river system, which came from the east, disappeared and a new Mesozoic river system began to dissolve the raw continent and carry its undried strata piecemeal eastward into the newly-created basin of the present Atlantic ocean." (p. 48.)

In the discussion of the Azoic rocks the statement is made that as far as the Pennsylvanian region is concerned, the irregularity is so great that it has been impossible "to classify its rocks into a series of formations, or even to show with any satisfaction the course of the outcrops on the map. All that can be said about them is that they are a badly crumpled-up mass of strata, of unknown thickness, all more or less thoroughly crystallized, of every grade of thick and thin-beddedness, of every tint of gray from nearly white to nearly black, with nearly every possible mixture of quartz, feldspar, hornblende, magnetite and mica, some of them being a syenite, some a granite, some a granulite, some a hornblende-schist, some a mica-schist, some a magnetic iron ore: and all of these kinds passing into one another, and overlying one another, as if the original sediments (if sediments they were) were of the most mixed and varied character, yet all derived from essentially one source, and belonging to one age, an age, moreover, not over-rich in lime and magnesia, if we may judge of it by the absence of crystalline limestone beds and beds of talc or serpentine." (pp. 67-68.)

The Archæan rocks are considered to be partly of volcanic and partly of sedimentary origin, and the arguments for or against each theory are very fully examined. The term Huronian as applied to a certain series of rocks is considered to be applicable only to those rocks exposed along the northern boundary of the United States. "Should a similar series appear in some other region and be called Huronian on account of the resemblance, the name would have no *time-value* whatever; unless we should imagine that in a so-called Huronian age the whole surface of the planet was stuccoed with a certain formation; and received successive coats of other kinds of rocks in after ages. And in fact this is a popular view, but absolutely false." (p. 157.)

So Prof. Lesley goes on to state what seems to be so often forgotten when strata of widely separated regions are correlated, how improbable it is that the sediments of two organic basins would be similar, remarking: "If Huronian strata existed elsewhere [than in the typical region] it would be around the Laurentian mass of the Adirondack mountains, in northern New York. But they are not to be found there. To say that they once covered the granite and gneiss of that country, but have been removed, would be to beg the question. It is not to be imagined that 18,000 or even 10,000 feet of such rocks could be removed without leaving a trace behind. The small exhibition of specular iron ore and slate in St. Lawrence county can not be accepted as an equivalent of

the Huronian system merely because it underlies the Potsdam sandstone and suggests the Marquette ores; especially in the face of the fact that Marquette iron ores are not represented in the section along lake Huron, nor do they immediately underlie the Potsdam sandstone on lake Superior." (p. 158.) Similar remarks are made on page 162.

As regards the Potsdam sandstone or Formation No. I, Prof. Lesley considers it to be unproved that the real Potsdam of New York extends as far as southern Pennsylvania, and he believes that the *Chiques sandstone* is the best name for the Pennsylvanian outcrop. It is the *Primal* sandstone of Rogers and is more of a quartzite than a sandstone. *Scolithus linearis* is the only fossil mentioned by Prof. Lesley, although others have since been found.

Following the discussion of the economic features of Formation No. I, mainly iron mines, is an interesting chapter on the *Great Valley* (Chap. XXII), and then is taken up the description of Formation No. II, the equivalent of the Calciferous, Chazy and Trenton of New York.

It would occupy too much space and extend this notice to an unreasonable length to note the many interesting facts presented by Prof. Lesley in his graphic style. Some things, however, seem worthy of special notice. In discussing, for example, the thickness of Formation No. IV, including the Oneida and Medina of the New York series, he notes the lack of uniformity in all oceanic deposits and enforces his statement with the following remarks:

"The bottom of a formation in one place may not exactly correspond to its bottom in another place; and the same is true of its top. Nature has never written its historical memoir of geological operations in distinct and well-rounded sentences; has never numbered and headed its chapters; has seldom drawn strong black lines between its paragraphs. The formations grade and fade away into each other; and that both downward and upward; and the geologist who attempts to measure any formation at any place must simply do his best to select some bottom rock to begin it with and some top rock to end it with. But in doing this he is always liable to mistake. He must make his own selections on his own responsibility. He can never confidently assert that the bottom and the top of his formations are established facts of science. When he multiplies his measurements of a formation in various places in order to obtain by comparison a knowledge of its variations in thickness, he subjects himself to the risk of multiplying his errors. Sometimes, indeed, a special bed at the bottom or at the top of a formation is so flagrantly different in constitution, in color, or in its fossil forms, from all the other beds near it that he can adopt it as a key rock with considerable confidence. But this is rarely the case; and even when such a key rock presents itself in one part of his district and another such key rock almost or exactly like it presents itself in another part of his district there is always a possibility that the two are not continuous; that they were not deposited at exactly the same time throughout the region; and that perhaps nature has repeated the deposit locally and subsequently." (p. 629.)

Paleontologists might object to this statement and say that fossils furnish a sure guide to the contemporaneity of formations. But it must not be forgotten that fossils are not strictly limited in range in many cases; and even when individual species are limited the fauna as a whole is not. Facts in geographical distribution at the present time should teach the difficulty and precariousness of generalizations as to range in former times. The genus *Sequoia* is living now in America, but it lived in Europe during the Tertiary. Were the species to become extinct now, a correlation of deposits in the two continents and their reference to the same time period would be obviously an error. This is only one instance out of many that might be cited.

The subject is still further considered by Prof. Lesley in his discussion of the separation of the Hudson River slate and Medina shales. In Bedford county the Oneida sandstone is absent and the Hudson River slates pass without any break into Medina shales. Hence the inference is drawn that as there is no indication of an elevation of the sea bottom to dry land, the absence of the Oneida "is really and surely due to the fact that the sediments were floated further out into deep water according to their fineness, until at length the finest material was exhausted, or, mingled with equally fine material, floated in from other directions." (p. 665.) At the Lehigh water-gap, while the Oneida is present, it rests conformably upon the Hudson River sandy slates, and these uppermost beds contain thin beds of sandstone, and there is thus a regular passage from the fine beds of the Hudson River to the coarser beds of the Medina; "and yet the transition is in fact instantaneous; as if a vast quantity of gravel was deposited upon a level sea bottom of dark sandy mud." (p. 676.)

So, too, at Port Jarvis, the Oneida and Medina pass into each other, by a series of alternations of white and red beds. "The bottom Medina beds (next over the Oneida) are all sandstone, made up of grains of quartz, some of them containing small pebbles of white quartz, interstratified with soft shales; while the upper Medina beds are nearly all reddish shale (much split by cross cleavage) interleaved with thick red and grayish sandstone beds" (p. 677).

The student of topography will find in Chapter LII (pp. 681-711) an interesting discussion of the topographical features of middle Pennsylvania. This is a mountainous region and the chapter is a succinct history of the mountains in their geological aspect.

Volume two is occupied with the Upper Silurian and Devonian formations as volume one was with the Laurentian, Cambrian and Lower Silurian. In Formation No. V, we find included the Clinton, Niagara and Salina of the New York system. The contacts of this with No. IV below and No. VI above are indefinite and difficult to locate. The general thickness of the formation is about 200 feet, but the local variations are very sudden and very great. The beds are mostly destitute of fossil remains. One remarkable feature is that the Niagara formation, so well developed in New York, can not be certainly recognized in Penn-

sylvania. The Clinton, on the other hand, is an important factor in the state inasmuch as it contains a large amount of iron ore.

The Lower Helderberg, Formation No. VI, while only a few hundred feet thick is interesting from its fossil remains. "A crisis in the Palæozoic history is approaching. The sea is shallowing. Living creatures are becoming more and more abundant. The smaller shells which lived before are replaced by, or have developed into larger shells: and among the trilobites appear articulated animals rivalling in size our modern lobsters. A world of coral-like animals flourish in extensive reefs: and the bed of the ocean becomes a floor of sponges. It is the age of Stromatopora and Eurypterus. Suddenly this wonderful exhibition comes to an end. An invasion of sharp sand grains with a proportion of clay and a tincture of lime, Formation No. VII [Oriskany of New York], invades the ocean and covers up the dead body of its animal life. Almost a new order of nature is inaugurated; new species and genera of animals appear; the great bucklered fish take possession of the sea; trilobites change their character and live in diminished numbers; black mud is poured from the rivers and settles upon the ocean bed: the first intimation of the creation of coal is given for a moment and then withdrawn: the great water basin deepens; and ten thousand feet of sandy and muddy deposits fill it up again; until, finally, the age of the true Coal Measures sets in and the Palæozoic record of the world is made complete" (pp. 898-899).

A graphic picture truly of geological change in the Lower Helderberg age. The variations in deposits, the great profusion of organic forms, and its wide distribution are all commented upon. The wonderful Stromatopora reef or bed is also discussed.

The Oriskany sandstone (*Areskana* is considered the correct name, p. 1034) is considered to mark the boundary between Palæozoic and Devonian strata. The Cauda-galli grit is regarded as probably the top member of the Oriskany rather than the basal member of the Upper Helderberg. This last is divided into seven beds, Corniferous, Marcellus, Hamilton, Tully, Genesee, Portage and Chemung, in ascending order, and each one is described in detail. Some interesting remarks on *Spirifera* are found on pages 1391-1395. In the Chemung occurs the Venango oil sand and this is described in great detail.

Prof. Lesley's work in this Final Summary closes at page 1853 in volume 3, and the remaining pages, devoted to the anthracite and bituminous coal fields, are by other hands. Mr. E. V. d'Invilliers describes the Mauch Chunk red shale, Pottsville conglomerate and the bituminous coal districts, while Mr. A. D. W. Smith untertakes the anthracite coal districts. The latter is considered first and the wonderful growth of the industry is manifest when it is noted that from 1840, when the annual product was about one million tons, it had increased in 1880 to 25,000,000 tons, and in 1893 to 48,185,306 tons. This was valued at $85,-687,078 and the vast amount was taken from an area of 484 square miles. It was exceeded only by the output of bituminous coal, valued at $122,-751,618, produced by mines covering an area of 200,000 square miles.

The great extent and value of the Carboniferous formations render detailed descriptions necessary, and as a consequence about 670 pages (1916 to 2588) are devoted to it. There are large numbers of sections and maps and the treatment is as exhaustive as could be made in the space at command. There is a noticeable lack of remarks, conclusions and suggestions such as characterize the first portion of the summary by Prof. Lesley.

The last part of the last volume is occupied by a description of the "New Red" rocks of Berks and Montgomery counties, by Benj. S. Lyman. It is a succinct account of this formation.

Taking the volumes as a whole, the "summary" is a success and a credit to the authors, especially to Prof. Lesley, and to the State. The great number of plates makes it useful and interesting to many who might find the text dry. Some typographical errors have crept in, but this is not surprising when the mass of material to be gone over is considered. J. F. James, M. D.

Higham, Mass., Aug. 27, 1896.

Good Ground, Long Island. The Montauk division of the Long Island railroad leaves the terminal moraine at Jamaica, going east, and runs south of it for the distance of about seventy miles until the station of Good Ground is reached, about a mile and a half west of the Shinnecock range of hills. The southeastern portion of the frontal plain—the overwash of the glacier—is almost valueless for agricultural purposes. Good Ground, as its name implies, seems to be an exception. On the fourth of July last, the writer paid a visit to this interesting locality for the purpose of observation. A short ride on the car from Eastport brought me to the station at Good Ground.

The terminal moraine lies between the station and Peconic bay, and a journey of about a mile and a half on foot brings the traveler to Squire's Grove, situated on the southern shore of this beautiful expanse of water above named. The so-called englacial till is not very deep, and covers stratified beds of sand and gravel which are exposed in the banks along the country road. The boulders are quite plentiful and lie very near the surface. They consist for the most part of gneissic granite, trap, and sandstone, doubtless brought over from Connecticut.

On nearing the bay, I could see the old familiar water channels branching out from it. One large arm stretches out through Squiretown to the southwest, forming a valley in which are some of the best farm lands. On reaching the beach, the inlet to the Canoe Place canal is about a mile to the east, with a high bluff intervening. Part of the bluff has been worn away by the inroads of the tides, and the beach is lined with boulders that lie like herds of cattle along the pebbly shore; many of them are larger than a good-sized ox. One can hardly realize that they have been transported so far from their native bed, and there is little wonder that the primitive mind regarded them with superstitious awe. The Long Island Indians had their legends as to their ori-

gin. It was said that his Satanic majesty, whose home it seems was on Long Island, had ventured over to the mainland at a place known as the "stepping stones." Having got in trouble with the spirits on the opposite side of the sound, he was forced to retreat; and, in order to have revenge, he gathered together all the stones he could find in the Coram hills, determined to hurl them at the heads of the primitive *yankees* on the opposite shore. It seems that the Evil One, however, failed to expend all of his ammunition, much of it having been left all along the north side of the island. The legend would account equally well for the scarcity of erratics on the side fronting the ocean.

It was natural, also, for early writers on the formation of the island to conjecture that, during some convulsion of nature, this small fragment of the American continent slid off from the mainland, as this little isle by the sea is chiefly composed of debris brought here from the regions north of the sound.

In my walk along the beach to the Canoe Place canal, I had time to examine the face of the bluff. The formations were somewhat obscured by washings from the clay deposit above: but it was easily seen that nearly the whole bluff, some fifty feet in hight, is composed of stratified sand and gravel with some thin layers of laminated clays. In previous papers published in the AMERICAN GEOLOGIST, I have called attention to the fact that, wherever the glacial floods were great, the material in consequence was carried farther southward, so here at Good Ground, where the moraine is much broken and indented by these old river channels, the marginal kames become quite prominent and run out as far south as the Shinnecock bay. Even the moraine proper, as we have noted, is very fluvial in character.

The Canoe Place depression nearly cuts the island in two. The Peconic and Shinnecock bays were doubtless at one time connected, and this connection has been restored by artificial means, a canal having been constructed across the narrow isthmus. A little further east, another arm of the Peconic bay stretches out towards Southampton, and between these two arms are embraced the Shinnecock hills. These are really marginal kames without the moraines. The till is very light and the soil therefore not so fertile as that of Good Ground, where the main morainic belt or "back bone" of this island has been more fully preserved.

The farmers of the south side of Long Island have learned, without knowing the cause, that the nearer they get to the ridge—the terminal moraine—the more fruitful is the soil. Of course glacialists will understand why this is so, as in general the glaciated portion is more productive than the unglaciated.

The region of the Shinnecock hills is full of interest, and it is worthy of note that the late Prof. James D. Dana, not long before his death, found the key that seems to unlock some of the mysteries of this wonder-land.* In a paper on Long Island sound in the Quaternary era, he

*Am. Journal of Science, third series, vol. 40, p. 426.

says:—"Along the middle third of the sound the depth in the larger part is only 10 to 15½ fathoms. There is near the southern shore, however, a depression of 20 to 25 fathoms. It ends with abruptness about a mile and a half from the shore with a depth of 18¼, 11½, 10, and 9 fathoms." This abrupt termination is thirty miles short of the outlet to the sound, and is nearly opposite the Mattituck pond, which almost connects with Peconic bay. Professor Dana was quite confident that a relationship existed between them in glacial times.

The present writer had arrived at the same conclusion by independent investigation. Not only this, but on a visit to Mattituck during the summer of 1893, I could see, what perhaps had never occurred to Dana, a connection between the Mattituck depression and Canoe Place. At least it was very suggestive that this break in the terminal moraine should occur nearly in a line with the deep depression referred to in the bed of the sound. The suggestion, of course, came naturally enough, as I had made a study of the same phenomenon on the west end of the island, where the bay depressions on the south side of the sound had been followed up through the moraines to the sea. All the connections between the Mattituck depression and Canoe Place are lost in the waters of Peconic bay; but when it is understood that the same conditions prevailed here, during the Glacial period, as on the west end of the island, the conclusion stated was easily arrived at. In fact, I had suggested this some years previously to my visit to Mattituck, and before I had seen Prof. Dana's paper in regard to the sound depression. In a pamphlet on the formation of Long Island, published in 1884, I said: "Block Island sound, Gardiner's, Great and Little Peconic bays, were originally formed by subglacial streams, that came from the mainland, and are merely the counterpart of the depressions and basins on the west end of the island." I mention this because it was very gratifying to find my conjecture seemingly confirmed by subsequent investigation.

The visit to Good Ground and Canoe Place was full of interest, not only on account of these geological problems, but there was much to remind me of my native home across the ocean, especially in the Shinnecock hills, which rise beyond Canoe Place to an elevation of 140 feet. Some writer has said, "Looking at them, where no villa is in sight, one is forcibly reminded of the description of the moors of Lorna Doone."

Eastport, L. I., N. Y. JOHN BRYSON.

A GRANITE BOULDER NEAR PITTSBURGH, PA. While geologizing around Carnegie, (formerly called Mansfield), in Allegheny Co., Penna., on August 30, this year, at a point just about 6 miles southwest of the confluence of the Allegheny and Monongahela rivers at Pittsburgh, namely about 500 feet northeast of Woodville station in Scott township on the P. R. R., in the bed of Scrubgrass run, I stumbled upon a very massive well-rounded erratic of red granite.

This boulder was partially embedded in the gravel and mud of the stream, but is apparently about 2 feet 9 inches in diameter, and proba-

bly weighs 1,100 or 1,200 lbs. A large area of its upper or exposed surface is fairly well-smoothed and striated. As at one place upon it there was a tendency to peel. I was able to knock off a small specimen, a part of which I have the pleasure to send you herewith. My reasons for believing that this boulder is a genuine glacial-period one, and nearly in place, may be stated thus:

1. In composition it is much like other erratics found north of the moraine as mapped by the Second Geological Survey of Pennsylvania.

2. It is in just such a position as erratics occur and are commonly seen in typical boulder-areas.

3. As above stated it bears marked evidence of glacial smoothing and scraping.

4. It is similar to other boulders in shape and form, namely, rounded.

5. Unlikely to have been derived from the bed of coal (the "Pittsburgh bed"), or its associated strata, which outcrop about 24 feet above the site at this place, and where there is a coal mine in operation: because most erratics found in or in contact with coal are stained black on the outside, while this one is not. Moreover I have never heard of a granite boulder having been found in the coal measures of western Pennsylvania, though I have seen one of limestone in the 10-inch bed of fireclay directly overlying the workable portion of the "Pittsburgh" bed at the Guffey mine about 20 miles to the south of Woodville; and possess one, of quartzite, that was taken out of the "Mammoth" bed of anthracite at Mount Carmel, Pa.

6. Such boulders are never shipped (at least I never heard of such a thing) in freight or coal cars, especially to coal-mines located in the country. Such a stone as this one would be very awkward to handle into a car, and I can conceive of no purpose or object in shipping such a thing at all excepting possibly to a museum.

The stones in the stream where this granite boulder was observed appeared to be all of coal-measure origin, namely,—limestone, sandstone, iron ore, grit, black slate, etc. The elevation of this boulder would be about 800 feet above tide level. The nearest erratic, (a small, smooth boulder composed of dark greenish, very hard, volcanic rock,) I have met with to the north of this red granite boulder, was on a hill side at New Brighton, Pa., a locality also several miles south of the line of the great moraine as mapped by the Penn. Geol. Survey.

This boulder therefore shows that the southern margin of the glacial moraine, as mapped in southwestern Pennsylvania, should be extended some 25 miles south, in that region. W. S. Gresley.

Erie, Pa., Sep. 30, 1896.

Mr. Sardeson and Fossil Tabulates. In the July number of the American Geologist, Mr. Sardeson does me the honor to reply to a critique of his paper, "Ueber die Beziehungen der fossilen Tabulaten zu den Alcyonarien." The fact that he there adduces one misstatement made by me and alleges others, seems to call for some notice on my part. In general, I wish to assure Mr. Sardeson that the unnamed

inaccuracies which he charges, were unintentional, that the purpose was anything but to show disrespect to himself or his reverend instructors, that the animus was only that which desires scientific truth, and the advanced and accurate methods which are calculated to secure it.

The single inaccuracy specifically mentioned will be found to be that of Mr. Sardeson himself, and is apparent only upon removing the expression quoted by him from its proper context. The paragraph in question reads as follows: "But the most serious arraignment I have to make of the general method employed is that in a paper of over one hundred pages, a paper which is systematic in its purpose if it is anything, the preëminent value of embryologic phases as phylogenetic factors is entirely overlooked or slighted. Indeed, the statement is so generally true that it may be made without modification, that nowhere has the writer used either embryologic stages or the succession of organic types in geologic time, as a proof, or as a check upon his work. Not only not performing investigations himself, but not even taking advantage of investigations already made, whether in the field of zoology or palæontology, he pursues a theoretic course independent of facts of supreme importance ready to his hand." (AMERICAN GEOLOGIST, vol. xviii, p. 38, line 33 et seq.) In this connection my meaning, I hope, is quite clear, that Mr. Sardeson has not directed his studies by truly phylogenetic principles, to the ontogeny of the individual. And this I believe is true. To state that he did not personally investigate the forms he discusses would be as great folly in me as it is in him to imply that I did so, and my own statement, if I had in mind to make such, would be contradicted by another on the next page (l. c., p. 39, line 43.) "To discuss a particular case, one to which Mr. Sardeson has given more personal study, perhaps than to any other, etc."

Indeed, I do not wish to impeach Mr. Sardeson as a careful and truth-telling observer; it is his deductions and his scientific method which in this case I call in question.

As to the apparent oversight of my own notes on Favosites, published in March, 1895 (AMERICAN GEOLOGIST, vol. xv, pp. 131-146), that is quite satisfactorily explained by Mr. Sardeson on the basis of its near contemporaneity with his own work. But the same is not true of the careful studies of Michelinia (Pleurodictyum) and Favosites published by C. E. Beecher in 1891 (Trans. Conn. Acad., vol. 8, p. 217.)

GEORGE H. GIRTY.

PERSONAL AND SCIENTIFIC NEWS.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY. MR. GEORGE H. BARTON has been appointed assistant professor of geology, and MR. AMADEUS W. GRABAU instructor in geology.

DR. J. W. SPENCER spent the past summer in Norway, giving much attention to geological observations, and returned in season to attend the meeting of the American Association.

MR. OSCAR H. HERSHEY, during September, has studied the Tertiary baseleveling, the glacial drift, and Quaternary changes of stream courses, in the upper Mississippi drainage area from St. Paul to Brainerd, Minn.

COST OF EUROPEAN GEOLOGICAL SURVEYS. Under this title MR. E. A. SCHNEIDER presents an article (which is to be continued) in the *Engineering and Mining Journal* for Oct. 16th. The surveys thus far mentioned are those of Russia and Germany.

STATE AND NATIONAL GEOLOGICAL SURVEYS. Under the title "Entwicklung, Organisation und Leistungen der geologischen Landesaufnahmen in der Vereinigten Staaten von Nordamerika," M. Klittke gives (*Zeitschrift für praktische Geologie*, June and August) an account of the various state and national organizations which have conducted geological work in the United States. All of the August number of the magazine (63 pages) is devoted to a description of the work and publications of the different state surveys.

MR. GEORGE F. BECKER, of the United States Geological Survey, has returned to Washington after an absence of six months in South Africa. He visited the diamond mines at Kimberley, but spent most of his time near Johannesburg, studying the gold deposits. A projected trip through the Chartered Company's territory was prevented by the Kaffir war. Mr. Becker expects to print some of his results during the winter, but probably in England, his data having been collected at the expense of English capitalists.—(*Science.*)

THE CHICAGO ACADEMY OF SCIENCES in June, 1892, decided to inaugurate the "Geological and Natural History Survey" of this Academy, the object being to investigate and report on the geology, topography, zoology and botany of the vicinity of Chicago. The first bulletin (The lichen-flora of Chicago and vicinity, by W. W. Calkins) of the Survey has already been issued. There are several other bulletins in course of preparation, the following relating to geological subjects: The drift of the Chicago area, by Frank Leverett: Boring records of Chicago and vicinity; Palæontology, by M. Fischer and W. C. Egan; Minerals, by C. M. Higginson.

PROF. ALEXANDER H. GREEN, the successor of Prestwich in the chair of Geology in the University of Oxford, died August 19, at the age of sixty-four years, having been born at Maidstone, Eng., Oct. 10, 1832. He was educated at Cambridge, and entered geological work as an assistant on the survey of Great Britain in 1861. where he served fourteen years. In 1875 he became professor of geology in the Yorkshire College, Leeds. As an author, Prof. Green was widely known for his excellent manual of Physical Geology, and he also contributed occasional papers to the Geological Magazine and the Quarterly Journal of the Geological Society.

MESSRS. J. E. SPURR, H. B. GOODRICH AND F. C. SCHRADER, of the United States Geological Survey, arrived in San Francisco this week [Oct. 17, 1896]. They were sent by the department to Alaska last spring to report on the prospects of quartz mining in that region. They crossed the Chilkat pass and reached the upper Yukon about the middle of June. Going down the Yukon river, and pursuing their investigations at the various mining settlements on their way, they reached Fort St. Michaels, at the mouth of the Yukon, three months ago. They believe that the prospects for profitable quartz mining are very good, and they will make a report to that effect.—(*Eng. and Mining Journal.*)

THE PEARY GREENLAND EXPEDITION OF 1896.

Lieut. Peary's expedition steamer Hope, which sailed in July with its party for scientific observations in Greenland, reached North Sydney, Cape Breton, September 26th. One division of the party, with Prof. George H. Barton, was landed for a considerable stay near Disco island; another, with Prof. Alfred Burton, at the Umanak fjord; and a third division, with Prof. Ralph S. Tarr, on the shore of Melville bay.

In *Science* for October 9th (pages 520-523), Prof. Tarr gives a brief narrative of the voyage, and notes of portions of his observations on Big island in Hudson strait, on the adjoining southern part of Baffin land, on the Nugsuak peninsula, and in the vicinity of the Devil's Thumb, Melville bay. He found evidences of the former extension of the Greenland ice-sheet beyond the extremity of the Nugsuak, to the Duck islands, eight to ten miles out to sea, where it had a thickness of not less than 800 feet at a distance of thirty-two miles from the limits of the present glaciation. In the retreat of the ice-sheet, which is now taking place, the glacial currents on the margin, under the influence of the minor topographic features, are in some places turned much aside or even quite opposite from the courses which they had during the farther extension of the ice.

It was found impossible to remove and bring the large mass of iron, thought to be a meteorite, to which Peary had been guided by the Eskimos in May, 1894, situated about twenty-five miles southeast of cape York. It is to be hoped that a geologic description of its locality may have been taken with sufficient fullness to determine whether that iron mass, and others a few miles farther eastward, may be of terrestrial origin, like the iron in equally large masses occurring farther south, at Ovifak, in basalt, and also weathered out from it, where they were long supposed to be fragments of a great meteorite. W. U.

The British Association Meeting in Liverpool.

The sixty-sixth annual meeting of the British Association for the Advancement of Science, held September 17 to 23 in Liverpool, under the presidency of Sir Joseph Lister, had an attendance of nearly 3,200, being one of the largest meetings of this Association. The address of Prof. J. E. Marr, president of Section C (Geology), reviewed the recent progress of stratigraphic geology. It is published in *Nature* for September 24, and in the *Geological Magazine* for October. Thirty-four papers were presented in this section, to which, also, fifteen committees, appointed at previous meetings, made reports on special subjects of geological investigation. Three papers related particularly to America, as follows:

Pre-Cambrian Fossils, especially in Canada. Sir J. W. Dawson.

Some Features of the Early Cambrian Faunas. G. F. Matthew.

The Highwood Mountains of Montana and Magmatic Differentiation: a Criticism. H. J. Johnston-Lavis.

Seven papers pertained to the Glacial period and to Quaternary geographic changes, including one by Prof. Edward Hull, on "Another possible Cause of the Glacial epoch."

In Section E (Geography) thirty-one papers were read, and two committees presented reports. The following papers were on American subjects:

Canada and its Gold Discoveries. Sir J. Grant.

The "Schomburgk Lines" in British Guiana. Ralph Richardson.

The Boundary Line between British Columbia and Alaska. E. Odlum.

Dr. F. P. Gulliver, of Norwich, Conn., read a paper in this section, on "The Coast-forms of Romney Marsh," describing the V-bar shingle ridges in the vicinity of Dungeness, Kent, on the Strait of Dover, which illustrate tidal action in the formation of cuspate forelands, as recently discussed by the author for the coast of America (Bulletin G. S. A., vol. VII, 1895, pp. 399–422).

Five days, next following the adjournment of this meeting, were occupied by an excursion of geologists, zoologists, botanists, and archæologists, in examining the Isle of Man, the geological party being led by Prof. Boyd Dawkins and Mr. G. W. Lamplugh.

The next meeting of the British Association, of which Sir John Evans is the president-elect, will be held in Toronto, Canada, beginning August 18, 1897. All members of the American Association, which will meet in Detroit, Mich., are invited to attend the Toronto meeting. For that purpose the Detroit meeting is to be during the week of August 9 to 14, an unusually early date. W. U.

F. B. Meek

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BIOGRAPHICAL SKETCH OF FIELDING BRADFORD MEEK.

By Charles A. White, Washington.

(Plate XII.)

Twenty years have passed since the death of Fielding Bradford Meek, and yet the few of his old associates whom the Old Reaper has spared still hold for him only the kindest remembrance. Scientists also, who did not know him personally, still give his works the same consideration and confidence that they were wont to accord while he was living. I shall make further reference to his personality, but it seems necessary to say at the outset that because of his indisposition to speak of his personal affairs, even to his intimate associates, it has been impracticable to obtain more that meager data of his personal history. This difficulty has been emphasized by the fact that his living kindred were so few and so distant that little or no information could be obtained from them.

The most complete account of his personal history that has been published is the one which I furnished to the American Journal of Science for its March issue immediately following his death. The circumstance of my getting even these few data from him is so apropos of his personal characteristics that I will relate it. One morning, only a few months before his death, while I was reviewing, with his aid, all the Smith-

sonian fossil collections, he seemed to be thinking upon something other than the work in hand. We were alone, sitting at opposite sides of a table, when he looked up to me and said: "Doctor, I had a very strange dream last night. I dreamed that I was sitting in my old room at home, when I suddenly heard in an adjoining room the notes of a piano, which were immediately accompanied with a song. The song was one with which I was familiar in my younger days, and I recognized the voice as that of my sister. She has been in her grave for thirty years, and my deafness is so complete that I have not heard a sound of any kind for a long time."

The circumstance was impressive, as was his manner in relating his dream; but after giving his feelings time to become a little composed I determined to make the occasion serve my long cherished purpose of getting from his own lips some account of his personal history. I accordingly said to him that, being younger than he, I should probably outlive him, and then I plainly asked him for the data I wanted, saying that in case of my survival I would publish them. He hesitated a little at first, but then in reply to my questions he gave me the following facts, to which he seemed disposed to confine his statements.

He was born in the city of Madison, Indiana, December 10, 1817. His grandparents were Irish Presbyterians, who removed to America from county Armagh about the year 1798 and, after a few moves, made their permanent home in Hamilton county, Ohio. There his father grew up to manhood and married, but with his young family he removed to Madison, where he became a lawyer of considerable eminence. The family, including the children who were born in Madison, consisted of the parents, two sons and two daughters, all of whom died several years before his own decease. The father died when Fielding was only three years old, leaving the family, not in want, but not in a condition to give the children so liberal an education as they desired.

Fielding's early youth was spent in the city of his birth, where he attended the best schools that were then established there, but his delicate health greatly interfered with his education. Still, the time of those years was not lost, for while they were passing the boy began to develop that love for nat-

ural science that was destined to distinguish him. Upon reaching manhood, by advice of his friends but against his own inclination, he invested his small patrimony in a mercantile business, first in Madison and then in Owensboro, Kentucky. The result was financial failure. After this, he labored at whatever he could find to do, struggling with poverty and ill health, but clinging to his beloved studies, which then included such fossils as were found in the region of his home. His whole thought was to learn, the idea of becoming himself an author not having yet dawned upon him. His studious habits became known, and when Dr. D. D. Owen organized his U. S. Geological Survey of Iowa, Wisconsin and Minnesota, he made young Meek one of his assistants, which position he held during the years 1848 and 1849.

Having completed his work to the satisfaction of Dr. Owen, he returned to his home in Owensboro, where he remained until 1852, when he went to Albany, N. Y., as assistant to Prof. James Hall in the paleontological work of that state. He had then not only acquired large knowledge of invertebrate fossils but he had become very skillful with his pencil in their delineation, and he entered upon his new work with great zeal. With the exception of three summers he remained with Prof. Hall continuously until 1858. Two of those summers were spent on the Geological Survey of Missouri, under the direction of Prof. G. C. Swallow, and the other, that of 1853, in exploring the bad-lands of Nebraska, in company with Dr. F. V. Hayden, both having been commissioned by Prof. Hall to do that work in his interests. Three years after that exploration he, in conjunction with Prof. Hall, prepared for publication by the American Academy of Arts and Sciences of Boston, an important memoir on Cretaceous fossils from Nebraska. This was really his first published paleontological work, and it was a worthy introduction to his subsequent career.

In 1858 Mr. Meek left Albany and went to Washington. D. C., where he resided until his death. At that time the needs of the Smithsonian Institution had not fully demanded the official use of all the rooms in its great building and the secretary, professor Henry, encouraged the gathering there of scientific workers, not only by offering them all its advantages

for study, but he allotted sleeping rooms to a few of them who had no family. One of these rooms was allotted to Mr. Meek when he first went to Washington, and he occupied it until his death, always sleeping there when not absent on professional work. It was in this room, in the front tower of the main Smithsonian building, that the greater part of his scientific life-work was accomplished.

The association which he formed with Dr. Hayden in their western exploration in 1853, was practically continued until Mr. Meek's death. When Dr. Hayden began his afterward famous geological explorations of the Rocky Mountain region and of the adjacent plains, he placed all his collections of inverterbrate fossils in Mr. Meek's hands for study; and although this work was wholly that of Mr. Meek, most of the results of such studies for several years were published under their joint names. The most important of these joint publications, "The Palæontology of the Upper Missouri," was issued by the Smithsonian Institution in 1865, and in many respects it was at that time the most exhaustive work of the kind that had been produced in America.

Notwithstanding his unbroken relation with Dr. Hayden, Mr. Meek declined to accept a regularly salaried position upon the survey organized by the former, preferring to command his own time and opportunities for doing inviting work in various fields. He thus did for the Geological Survey of Illinois much the greater part of the work on invertebrate fossils that characterizes that fine series of reports, although it was published under the joint names of Meek and Worthen. Other important work upon paleozoic fossils was done by him for the Geological Survey of Ohio.

A very large part of his work, however, was done upon fossils of later age, and only a few months before his death he finished what he regarded as the most important work of his life, namely, "A Report on the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country." This work constitutes volume IX of the quarto series of the U. S. Geological Survey of the Territories, and contains more than 600 pages of text, and 45 plates of illustrations.

It is not necessary here to speak at length of the character of Mr. Meek's scientific labors because the twenty years that

have passed since he laid down his pen have not diminished the esteem in which they are held by those competent to judge of their merit. It is enough to say that thoroughness, scrupulous exactness, nice powers of discrimination, and a comprehensive grasp of his subject, are manifested in all his writings; and with such merits his works will shed luster upon his name as long as paleontology shall be studied.

Mr. Meek was never robust in health, and for a large part of his life he was an invalid, his malady being pulmonary tuberculosis. As age advanced his periods of exhaustion became more frequent and more pronounced until they ended in death. He died in Washington on the 21st of December, 1876, and was buried in the Congressional Cemetery, in the eastern suburb of Washington. His funeral was held in a hall of the Smithsonian Institution, professor Henry having delivered the funeral oration. In person he was moderately tall, rather slender, of erect and dignified bearing, but as his malady increased, his carriage became less free. Although he was never strong and often ill he never complained, was always cheerful, always hopeful, and always devoted to his scientific work, which he dearly loved. He was genial and sincere, pure minded and honorable. Gentleness and candor were apparent in every lineament of his face and in every word he uttered; but he was self reliant and ready at all times to defend what he believed to be right, and with his keen sense of justice he was seldom mistaken as to what was right.

His hearing began to fail in early manhood and the affliction increased until total deafness occurred, several years before his death. The paleobotanist, Lesquereux, who was also deaf during a great part of his life, learned to converse orally by watching the motion of the lips of the speaker, but Mr. Meek never learned to do this, and he even seemed averse to the use or recognition of any conventional signs. Still, he was always ready and eager to converse with his friends, and he always kept at hand a pad of paper and a pencil for their use.

Although he was thus cut off from the oral conversation of his friends he never referred to it as a hardship. Because of this affliction, however, and of his natural diffidence, he rarely, if

ever, attended social gatherings. He never married and seemed disinclined to female society, but if brought into the presence of ladies no one was more courteous and respectful than he. He was rigorously circumspect in all his acts and conversation, and as chaste in every word and thought as if the fruit of the Vitex had found a place on his daily bill of fare.

In dress he was plain, but neat, preferring the costume prevalent in his early manhood. He wore a broadcloth cloak in cold weather, and always wore a silk hat, as seen in the accompanying portrait. Indeed, to protect his head from drafts of air, to which he was peculiarly sensitive, he so often wore his hat in the house that his friends declared that his portrait would look unnatural without it. So, when he sat to the photographer, he good-naturedly complied with their request and kept his hat on. He was never miserly, but his habits were so frugal that at the time of his death he had accumulated a competence which was quite sufficient for all his needs, even if he had lived to great old age.

He seemed to have had no morbid fear of death, but he evinced much unwillingness to make any provision for the disposition of his property with reference to that event. None of his friends, not even professor Henry, who had great influence with him, could induce him to make his will. The result was that after long search his legal executor was able to find a distant relative who could legally take possession of the property. The Smithsonian Institution bought from that heir Mr. Meek's library, and this closed the business affairs of a laborious and frugal life, but which was only a subjunctive corollary of a noble, intellectual life.

In looking back from this distance of time upon the life that I have briefly sketched, one is impressed with its apparent early failures and with its really great success, a success that is full of encouragement to struggling early manhood. Still few men will be so long remembered for eminent ability and sterling and loveable personal qualities as Fielding Bradford Meek.

Catalogue of Mr. Meek's published writings, arranged chronologically.

1855.

Report on Moniteau county. First and Second Annual reports of the Geological Survey of Missouri. By G. C. Swallow, State Geologist. Part II, pp. 96-117. Jefferson City.

1856.

Descriptions of new species of fossils from the Cretaceous formations of Nebraska; with observations upon Baculites ovatus and B. compressus, and the progressive development of the septa in Baculites, Ammonites and Scaphites, (with James Hall). Mem. Acad. Arts and Sci., vol. V, new series, pp. 379-411, and 8 plates. Cambridge.

1857.

Descriptions of new species of Gasteropoda from the Cretaceous formation of Nebraska Territory, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad., vol. VIII, pp. 63-69. Philadelphia.

Descriptions of new species of Gasteropoda and Cephalopoda from the Cretaceous formations of Nebraska Territory, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad., vol. VIII, pp. 70-72. Philadelphia.

Descriptions of twenty-eight new species of Acephala and one Gasteropod, from the Cretaceous formations of Nebraska Territory, (with F. V. Hayden). Proc. Acad. Nat. Sci.. Philad., vol. VIII, pp. 81-87. Philadelphia.

Descriptions of new species of Acephala and Gasteropoda from the Tertiary formations of Ñebraska Territory; with some general remarks on the geology of the country about the sources of the Missouri river, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad., vol. VIII, pp. 111-126. Philadelphia.

Descriptions of new fossil species of Mollusca collected by Dr. F. V. Hayden in Nebraska Territory; together with a complete catalogue of all the remains of invertebrata hitherto described and identified from the Cretaceous and Tertiary formations of that region, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad., vol. VIII. pp. 265-286. Philadelphia.

1858.

Description of new organic remains from the Cretaceous rocks of Vancouver island. Trans. Albany Institute, vol. IV, pp. 37-49. Albany.

Descriptions of new species and genera of fossils collected by Dr. F. V. Hayden in Nebraska Territory, under the direction of Lieut. G. K. Warren, U. S. Topographical Engineers; with some remarks on the Tertiary and Cretaceous formations of the Northwest and the parallelism of the latter with those of other portions of the United States and Territories, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad., vol. IX, pp. 117 148. Philadelphia.

Description of new organic remains from northern Kansas, indicating the existence of Permian rocks in that territory. Trans. Albany Institute, vol. IV, pp. 73-88. Albany.

Fossils of Nebraska. Letter from F. B. Meek and F. V. Hayden to G. K. Warren, Lieut. Topog. Eng., dated Washington, February 8,

1858; printed in the National Intelligencer of March 16, (with F. V. Hayden). Am. Jour. Sci., vol. xxv, 2d Ser. pp. 439-442. New Haven.

1859.

Descriptions of new organic remains collected in Nebraska Territory in the year 1857, by Dr. F. V. Hayden, geologist to the exploring expedition under the command of Lieut. G. K. Warren, Topo. Eng., U. S. Army, together with some remarks on the geology of the Black Hills and portions of the surrounding country, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad. vol. x, pp. 41-50. Philadelphia.

Remarks on the Lower Cretaceous beds of Kansas and Nebraska, together with descriptions of Carboniferous fossils from the valley of Kansas river, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad., vol x, pp. 256-264. Philadelphia.

1860.

Geological explorations in Kansas Territory, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad., vol. xi, pp. 8-30. Philadelphia.

On a new genus of Patelliform shells from the Cretaceous of Nebraska, (with F. V. Hayden). Am. Jour. Sci., vol. xxix, 2d Ser., pp. 33-35, plate i. New Haven.

1861.

Descriptions of new organic remains from the Tertiary, Cretaceous and Jurassic rocks of Nebraska, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad., vol. xii, pp. 175-184. Philadelphia.

Description of new fossil remains collected in Nebraska and Utah by the exploring expedition under the command of Capt. J. H. Simpson, of the U. S. Topographical Engineers (extracted from that officer's forthcoming report). Proc. Acad. Nat. Sci., Philad., vol. xii, pp. 308-315. Philadelphia.

Systematic catalogue with synonymy, etc., of Jurassic, Cretaceous and Tertiary fossils collected in Nebraska by the exploring expedition under the command of Lieut. G. K. Warren, of U. S. Topographical Engineers, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad., vol. xii, pp. 417-432. Philadelphia.

Descriptions of new species of Crinoidea and Echinoidea from the Carboniferous rocks of Illinois and other western states, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. xii, pp. 379 397. Philadelphia.

Descriptions of new Carboniferous fossils from Illinois and other western states, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. xii, pp. 447-472. Philadelphia.

Remarks on the age of the Goniatite limestone at Rockford, Indiana, and its relation to the "Black Slate" of the western states and to some of the succeeding rocks above the latter, (with A. H. Worthen). Am. Jour. Sci., vol. xxxii, 2d Ser., pp. 167-177. New Haven.

1862.

Descriptions of new Paleozoic fossils from Illinois and Iowa, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. xiii, pp. 128-148. Philadelphia.

Descriptions of new Cretaceous fossils collected by the Northwestern Boundary Commission on Vancouver and Sucia islands. Proc. Acad. Nat. Sci., Philad., vol. XIII, pp. 314-318. Philadelphia.

Descriptions of new Lower Silurian (Primordial), Jurassic, Cretaceous and Tertiary fossils, collected in Nebraska by the exploring expedition under the command of Capt. Wm. F. Raynolds, U. S. Top. Engrs., with some remarks on the rocks from which they were obtained, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad., vol. XIII, pp. 415-447. Philadelphia.

1863.

Remarks on the Family Actæonidæ, with descriptions of some new genera and subgenera. Am. Jour. Sci., vol. XXXV, 2d Ser., pp. 84-94. New Haven.

Descriptions of new Cretaceous fossils from Nebraska Territory, collected by the expedition sent out by the government under the command of Lieut. John Mullan, U. S. Topographical Engineers, for the location of a wagon road from the sources of the Missouri to the Pacific ocean, (with F. V. Hayden). Proc. Acad. Nat. Sci., Philad., vol. XIV, pp. 21-28. Philadelphia.

1864.

Remarks on the family Pteriidæ (Aviculidæ), with descriptions of some new fossil genera. Am. Jour. Sci., vol. XXXVII, 2d Ser., pp. 212-220. New Haven.

Carboniferous and Jurassic fossils. Palæontology of California (Whitney), vol. I, pp. 1-16, 3 plates and pp. 39-53, plates VII and VIII. Published by authority of the California Legislature.

1865.

Palæontology of the Upper Missouri, (with F. V. Hayden). Smithsonian contributions to Knowledge (172), pp. 1-135, plates I-V, Washington.

Description of fossils from the Auriferous slates of California Geol. Surv. California, Geology, vol. I, (Appendix B), pp. 477-482, 1 plate. Published by authority of the California Legislature.

Remarks on the Carboniferous and Cretaceous rocks of eastern Kansas and Nebraska and their relations to those of the adjacent states and other localities farther eastward, in connection with a review of a paper recently published on this subject by M. Jules Marcou, in the Bulletin of the Geological Society of France. Am. Jour. Sci., vol. XXXIX, 2d Ser. pp. 157-174. New Haven.

Note in relation to a genus of Crinoids from the Coal Measures of Illinois and Nebraska, proposed by them on page 174 of this volume of the Journal, (with A. H. Worthen). Am. Jour. Sci., vol XXXIX, 2d Ser., p. 350. New Haven.

Preliminary notice of a small collection of fossils found by Dr. Hayes on the west shore of Kennedy channel, at the highest northern localities ever explored. Am. Jour. Sci., vol. XL, 2d Ser., pp. 31-34. New Haven.

Notice of some new types of organic remains from the Coal Measures of Illinois, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. XVII, pp. 41-53. Philadelphia.

Remarks on the genus Taxocrinus (Phillips) McCoy, 1844; and its relation to Forbesiocrinus de Koninck and Le Hon, 1854, with descriptions of new species, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. XVII, pp. 138–143. Philadelphia.

Descriptions of new species of Crinoidea, etc., from the Paleozoic rocks of Illinois and some of the adjoining states, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad.. vol. XVII, pp. 143–155. Philadelphia.

Descriptions of new Crinoidea, etc., from the Carboniferous rocks of Illinois and some of the adjoining states, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. XVII, pp. 155–156. Philadelphia.

Note on the genus Gilbertsocrinus (Phillips). Proc. Acad. Nat. Sci., Philad., vol. XVII, pp. 166–167. Philadelphia.

Contributions to the paleontology of Illinois and other western states, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. XVII, pp. 245–273. Philadelphia.

Observations on the microscopic shell structure of Spirifer cuspidatus Sowerby, and some similar American forms. Proc: Acad. Nat. Sci., Philad., vol. XVII, pp. 275–277. Philadelphia.

1866.

Note on the affinities of the Bellerophontidæ. Proc. Chicago Acad. Sci., vol. I, pp. 9–11. Chicago.

Contributions to the paleontology of Illinois and other western states, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. XVIII, pp. 251–275. Philadelphia.

Descriptions of Paleozoic fossils from Devonian and Carboniferous rocks of Illinois and other western states, (with A. H. Worthen). Proc. Chicago Acad. Sci., vol. I, pp. 11–23. Chicago.

Descriptions of Invertebrates from the Carboniferous system, (with A. H. Worthen). Geological Survey of Illinois, vol. II, pp. 145–411, plates 14–20, and 23–32. Springfield.

1867.

Check-lists of the Invertebrate fossils of North America, Cretaceous and Jurassic. Smithsonian Miscellaneous Collections (No. 177), pp. 1–40. Washington.

Check-lists of the Invertebrate fossils of North American Miocene. Smithsonian Miscellaneous Collections (No. 183), pp. 1–32. Washington.

Note on Bellinurus Danæ from the Illinois Coal Measures. Am. Jour. Sci., vol. XLIII, 2d Ser., pp. 257, 258. New Haven.

Note on a new genus of fossil Crustacea. Am. Jour. Sci., vol. XLIII, 2d Ser., pp. 394, 395. New Haven.

On the punctate shell-structure of Syringothyris. Am. Jour. Sci., vol. XLIII, 2d Ser., pp. 407, 408. New Haven.

Remarks on Prof. Geinitz's view respecting the Upper Paleozoic rocks and fossils of southern Nebraska. Am. Jour. Sci., vol. XLIV, 2d Ser.. pp. 170–187; continued, pp. 327–339; notes to same, pp. 282, 283. New Haven.

Notes on the genus Palæacis Haine, 1860, (Sphenopoterium M. and W., 1866). Am. Jour. Sci., vol. XLIV, 2d Ser., pp. 419, 420. New Haven.

Fossils from the west coast of Kennedy Channel. Hayes's "Open Polar Ocean," p. 341. London.

1868.

Preliminary notice of a remarkable new genus of corals, probably typical of a new family; forwarded for study by Prof. J. D. Whitney from the Silurian rocks of Nevada Territory. Am. Jour. Sci., vol. XLV, 2d Ser., pp. 62–64. New Haven.

Note on the shell structure and family affinities of the genus Aviculopecten. Am. Jour. Sci., vol. XLV, 2d Ser., pp. 64, 65. New Haven.

Preliminary notice of a Scorpion, a Eurypterus (?) and other fossils, from the Coal Measures of Illinois, (with A. H. Worthen). Am. Jour. Sci., vol. XLVI, 2d Ser., pp. 19–28. New Haven.

Note on Ethmophyllum and Archæocyathus. Am. Jour. Sci., vol. XLVI, 2d Ser., p. 44. New Haven.

Notes on some points in the structure and habits of the Paleozoic Crinoidea, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. XX, pp. 323–334. Philadelphia.

Remarks on some types of Carboniferous Crinoidea, with descriptions of new genera and species of the same, and of one Echinoid, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. XX, pp. 335–359. Philadelphia.

Paleontology, (with A. H. Worthen). Geological Survey of Illinois, vol. III, pp. 291–565, plates 1–20. Springfield.

1869.

Remarks on the geology of the valley of Mackenzie river, with figures and descriptions of fossils from that region in the museum of the Smithsonian Institution, chiefly collected by the late Robert Kennicott, Esq. Trans. Chicago Acad. Sci., vol. I, pp. 61–114, plates XI–XV. Chicago.

Notes on some points in the structure and habits of the Paleozoic Crinoidea, (with A. H. Worthen). Am. Jour. Sci., vol. XLVIII, 2d Ser., pp. 23–40. New Haven.

Descriptions of new Crinoidea and Echinoidea from the Carboniferous rocks of the western states, with a note on the genus Onychaster, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. XXI, pp. 67–83. Philadelphia.

Remarks on the Blastoidea with descriptions of new species, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. XXI, pp. 83-91. Philadelphia.

Notes on some points in the structure and habits of the Paleozoic Crinoidea, (with A. H. Worthen). Canad. Nat., new series, vol. IV, pp. [Reprints from entries 57 and 61.]

1870.

Note on the relations of Synocladia, King. 1849, to the proposed genus Septopora, Prout, 1858, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. XXII, pp. 15–18. Philadelphia.

Descriptions of new species and genera of fossils from the Paleozoic rocks of the western states, (with A. H. Worthen). Proc. Acad. Nat. Sci., Philad., vol. XXII. pp. 22–56. Philadelphia.

Descriptions of fossils collected by the U. S. Geol. Survey, under the charge of Clarence King, Esq. Proc. Acad. Nat. Sci., Philad., vol. XXII, pp. 56–64. Philadelphia.

Geology of the line of the Great Pacific railroad. [In a letter to Dr. J. J. Bigsby.] Geological Magazine, Decade I, vol. VII, pp. 163, 164. London.

1871.

A preliminary list of fossils collected by Dr. Hayden in Colorado, New Mexico and California, with brief descriptions of a few of the new species. Am. Philos. Soc., Philad., vol. XI, pp. 425–431. Philadelphia.

Preliminary notice of a new species of Trimerella from Ohio. Am. Jour. Sci., vol. 1, 3d Ser., pp. 305, 306. New Haven.

On some new Silurian Crinoids and shells. Am. Jour. Sci., vol. II, 3d Ser., pp. 295–302. New Haven.

Descriptions of new species of invertebrate fossils from the Carboniferous and Devonian rocks of Ohio. Proc. Acad. Nat. Sci., Philad., vol. XXIII, pp. 57–93. Philadelphia.

Descriptions of new species of fossils from Ohio and other western states and territories. Proc. Acad. Nat. Sci., Philad., vol. XXIII, pp. 159–184. Philadelphia.

Notice of a new Brachiopod from the lead-bearing rocks at Mine La Motte, Missouri. Proc. Acad. Nat. Sci., Philad., vol. XXIII, pp. 185–187. Philadelphia.

Descriptions of new Paleozoic fossils, mainly from the Cincinnati Group of the Lower Silurian series of Ohio. Proc. Acad. Nat. Sci., Philad., vol. XXIII, pp. 308–336. Philadelphia.

List of Carboniferous fossils from West Virginia, with descriptions of new species. Appendix B, Report of Regents of West Virginia University for 1870, pp. 67–73. Wheeling.

Remarks on the genus Lichenocrinus. An. and Mag. Nat. Hist., Ser. 4, vol. VIII, pp. 341–345. London.

Preliminary Paleontological report, consisting of lists of fossils with descriptions of some new types, etc. Prelim. Rep. U. S. Geol. Survey of Wyoming and contiguous territories, pp. 287–318. Washington.

1872.

Supplementary note on Lichenocrinus. An. and Mag. Nat. Hist., Ser. 4, vol. IX. pp. 247, 248. London.

Supplementary note on the the genus Lichenocrinus. Am. Jour. Sci., vol. III, 3d ser., pp. 15–17. New Haven. [See next preceding entry.]

Descriptions of some new types of Paleozoic shells. Am. Jour. Conch., vol. VII, pp. 4–10, 1 plate. Philadelphia.

Descriptions of two new star fishes and a Crinoid, from the Cincinnati Group of Ohio and Indiana. Am. Jour. Sci., vol. III, 3d Ser., pp. 257–262. New Haven.

Descriptions of new species of fossils from the Cincinnati Group of Ohio. Am. Jour. Sci., vol. III, 3d Ser., pp. 423–428. New Haven.

Descriptions of a few new species and one new genus of Silurian fossils from Ohio. Am. Jour. Sci., vol. IV, 3d Ser., pp. 274–281. New Haven.

Preliminary list of fossils collected by Dr. Hayden's exploring expedition of 1871 in Utah and Wyoming Territories, with descriptions of a few new species. Prelim. Rep. of U. S. Geol. Survey of Montana and portions of adjacent territories, pp. 373-377. Washington.

Report on the paleontology of eastern Nebraska, with some remarks on the Carboniferous rocks of that district. Final Report of the U. S. Geological Survey of Nebraska and portions of the adjacent territories, pp. 83-239, and eleven plates. Washington.

1873.

[Geological Reports on Miller, Morgan and Saline counties, Missouri.] Reports on the Geological Survey of the state of Missouri, 1855-1871, by G. C. Broadhead, F. B. Meek and B. F. Shumard, chapters 7-9, pp. 111-188. Jefferson City.

Spergen Hill fossils identified among specimens from Idaho. Am. Jour. Sci., vol. v, 3d Ser., pp. 383, 384. New Haven.

Preliminary paleontological report, consisting of lists and descriptions of fossils, with remarks on the ages of the rocks in which they were found, etc., etc. Sixth An. Rep. U. S. Geol. Surv. Terr., pp. 431-518. Washington.

Descriptions of invertebrate fossils of the Silurian and Devonian systems. Geol. Survey, Ohio, vol. I, part II. Paleontology, pp. 1-243, plates 1-23, and three plates of diagrams of Crinoids. Columbus.

Paleontology. Descriptions of Invertebrates from the Carboniferous system, (with A. H. Worthen). Geological Survey of Illinois, vol. v, pp. 323-619, plates I-XXXII. Springfield.

1874.

Notes on some of the fossils figured in the recently issued Fifth volume of the Illinois State Geological Report. Am. Jour. Sci., vol. VII, 3d Ser., pp. 189-193; continued on pp. 369-376, and 484-490 and 580-584. New Haven.

The new genus Euchondria. Am. Jour. Sci., vol. VII, 3d Ser., p. 445. New Haven.

[Description of] Pleurotomaria Taggarti. An. Rep. U. S. Geol. Survey Terr., for 1873, p. 231, foot note. Washington.

1875.

Notes on some fossils from near the eastern base of the Rocky mountains, west of Greeley and Evans, Colo., and others from about 200 miles further eastward, with descriptions of a few new species. Bull. U. S. Geol Surv. Terr., 2d Ser., No. 1., pp. 39-47. Washington.

Description of Unios supposed to be of Triassic age. Ann. Rep. Geog. and Geol. Expls. and Surveys west of the 100th Meridian, 4°, vol. III, Geology, pp. 182, 183. Washington.

A Report on some of the Invertebrate fossils of the Waverly Group and Coal Measures of Ohio. Rep. Geol. Surv. Ohio, vol. II, part II, Paleontology, pp. 269-347, plates X-XX. Columbus.

Description of Olenellus gilberti and O. howelli. Rep. Geogr. and Geol. Expls. and Surveys west of the 100th Meridian, 4°, vol. III, Geology, pp. 82, 83. Washington.

Paleontology of Illinois. Descriptions of Invertebrates, (with A. H. Worthen). Geol. Surv. Illinois, vol. VI, Sec. 2, pp. 491–532: plates 23–32. Springfield.

Notice of a very large Goniatite from eastern Kansas, (Carboniferous). Bull. U. S. Geol. Surv. Terr., No. 6. 2d Ser., vol. I, p. 445. Washington.

1876.

Descriptions and illustrations of fossils from Vancouver and Sucia islands and other northwestern localities. Bull. U. S. Geol. Surv. Terr., vol. II, No. 4, pp. 351–374, and 6 plates. Washington.

Note on the new genus Uintacrinus, Grinnell. Bull. U. S. Geol. Surv. Terr., vol. II, No. 4, pp. 375–378. two wood cuts. Washington.

Descriptions of the Cretaceous fossils collected on the San Juan exploring expedition under Capt. J. N. Macomb, U. S. Engineers. Report of the Exploring Expedition from Santa Fé, New Mexico, to the junction of the Grand and Green rivers of the Great Colorado of the West, in 1859, pp. 121–133, plates 1 and 2. Washington.

Report on the Paleontological collections of the expedition. Rep. Expl. Great Basin of Utah in 1859. By J. H. Simpson. Apendix J., pp. 337–373, plates I–IV. Washington.

A report on the Invertebrate Cretaceous and Tertiary fossils of the upper Missouri country. U. S. Geol. Surv. Terr., vol. IX, 4°, pp. I–XIV. and 1–629, plates 1–45. Washington.

1877.

Paleontology. U. S. Geol. Expl. 40th Parallel, vol. 4, part 1, pp. 1–197, plates 1–17. Washington.

NOTE.—This work was published after Mr. Meek's death, but he had completed it more than a year previously.

STRATIGRAPHY AT SLATE'S SPRINGS WITH SOME FARTHER NOTES ON THE RELATION OF THE GOLDEN GATE SERIES TO THE KNOXVILLE.

By H. W. FAIRBANKS, Berkeley, Cal.

In the fall of 1895 the writer revisited Slate's Springs in company with Dr. Palache for the double purpose of determining in greater detail the stratigraphic position of the slates and collecting better paleontological material. The important bearing of the fauna found there upon the correct determination of the age of the Golden Gate series is an excuse for presenting the following notes.

The beds in question occur as a narrow fringe along the most rugged portion of the Monterey coast, and rest against the crystalline complex of the Santa Lucia range. This section was first visited by the writer in 1893, when several frag-

ments of an *Inoceramus* were found in the ocean cliffs beneath the sulphur springs. In 1894 this locality was again examined and a collection of five species of molluscs made in addition to some poorly preserved plants.* It was hoped that these would be indicative of some definite geological horizon, but all the species were found to be new and uncertain in their time range, though presenting a Cretaceous rather than a Jurassic aspect. One species of Inoceramus among the lot appeared to be closely allied to a Cretaceous form. The apparent conflict between the stratigraphy and the paleontological evidence tended to discredit the correctness of the field work. The writer had however felt most thoroughly convinced from the beginning that there could be no doubt about the propriety of referring the strata at Slate's Springs to a pre-Cretaceous horizon (Golden Gate series) the rocks of which are so widely developed through the Coast ranges. These beds are believed to be continuous with the older rocks of Pine mountain. During the recent trip this mountain was revisited and the marked contrast between the *Aucella*-bearing sandstone and shale, with distinct and regular bedding, and the distorted and sheared rocks of the underlying Golden Gate series was more strongly impressed upon the writer than ever before. About the slopes of the mountain the knobs of hard and often silicified sandstone project up through the Knoxville presenting the greatest contrast imaginable, with the shales and sandstone of the latter formation. In addition to the non-conformity on the south side of the mountain† there occur on the north side pebbly conglomerates containing abundant fragments of the red jasper which is so plentiful in the Golden Gate series in this vicinity.

The pre-Cretaceous rocks extend continuously northward from Pine mountain forming all the western portion of the Santa Lucia range as far as Vicente creek. Here the series rapidly narrows and for a short distance south of Mill creek has an exposed thickness of less than 1,000 feet. At Mill creek it is somewhat greater but the metamorphism has been so intense that it is rather difficult to draw the line between

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*Jour. of Geol. vol. III, p. 423.
†Jour. of Geol. vol. III, p. 421.

it and the crystalline schists of the older complex. North of Mill creek the series widens to about three miles and contains many bodies of greenish and reddish jasper. At Cañon Diablo it narrows again, being folded in between ridges of the older rocks. On the mountain slope between the two forks of the cañon the southernmost exposures of the basal conglomerate were observed. North of the cañon the series widens to more than half a mile. The conglomerate rises along the slope of the mountains to an elevation of fully 1,500 feet two miles south of Slate's Springs. From that point it gradually sinks and disappears three miles north of the springs. Silicified sandstones and jasper appear along the trail north from Cañon Diable leading to Dolan's. On the coast near Dolan's there is exhibited the most intense silicification and shearing of the sandstones and shales observed at any point along the coast. From this point to Slate's Springs, a distance of two miles, the series gradually narrows and exhibits less silicification and shearing. About three fourths of a mile south of the springs the strike of the strata carries the jasper beds beneath the sea. A little north of this spot the underlying strata consist of alternations of thin bedded sandstone and slate, with dip either approximately vertical or to the northeast, in the latter case indicating an overthrow. In the slate probably not more than 300 feet below the jasper beds were found specimens of *Inoceramus* similar to those below the springs. This fossil seems to be the most abundant, aside from the plant remains, being found in the slates as far as they were traced, a distance of about four miles. Some specimens of this genus reach a diameter of nearly a foot. Such has been the shearing and compression to which the strata have been subjected that the larger fossils have been generally flattened out, although the smaller ones are occasionally fairly well preserved. The main body of slate with layers of thin bedded sandstone has a thickness of about 50 feet, through the greater portion of which the fossils are scattered. The slates were traced to a distance of about three miles north of the springs and were found to contain fossil remains at nearly all points where they could be examined. A stratum of very hard coarse sandstone furnished a number of very poorly preserved molluscan remains. Nearly a dozen species

in all were found in addition to the plant remains, although only a part of them can be even generically determined. The labor of collecting was very great for the specimens are sparingly disseminated through the thickness of slate mentioned.

It seems that there can no longer be any question as to the true stratigraphic position of these beds, that is, that they represent a lower horizon than the jaspers.

The exposure of the strata for five miles with Slate's Spring as a center is an interesting one for study. The characteristic shearing and silicification are well shown, while there are most excellent examples of faulting, flexing, and squeezing out of the strata. The basal conglomerate is composed largely of boulders derived from the crystalline rocks forming the Santa Lucia range. In some of the finer conglomerates there are pebbles of an uncrystalline argillaceous rock, pointing to an earlier horizon now hidden. Argillaceous patches, somewhat thready at times are numerous in the sandstone. Some of them appear to be of foreign inclusions, while others may represent portions of the argillaceous strata mixed with the sandstone during shearing, although at present the sandstone appears to be perfectly massive.

The very close resemblance of these beds at Slate's Springs to the strata at the base of the same series at point San Pedro, even to the inclusion of shaly fragments make it appear that both probably belong to about the same horizon.

Eagle Ranch and Vicinity.

Following the trip just described the Eagle Ranch, San Luis Obispo county, was visited and added proof acquired of the unconformable position of the Golden Gate series beneath the Knoxville. Just west of the ranch house a pebbly sandstone containing *Aucella* was found at the base of the Knoxville and overlying the shales, sandstones, and jaspers of the former series. On the head of the Atascadero as well as on Toro creek the Knoxville shales appear in clean cut contact with the green eruptives of the older series. No trace of metamorphism was apparent in any case.

Berryessa Cañon.

An excellent section of the Golden Gate series is shown in Berryessa cañon in eastern Napa county. The Berryessa creek cuts through a high ridge of the older rocks, exposing on

either side the shales and sandstone of Knoxville age. On the west the latter beds appear in the form of a syncline extending northwest and southeast, with a width of a mile and a half. A dike of serpentine separates it not only from the ridge through which Berryessa creek runs but also from the mountains bordering Napa valley on the east. At the entrance to the upper end of the cañon slaty shale is abundant but farther down sandstone predominates. The strata are steeply inclined through nearly the whole cañon and show strongly the effects of shearing and fracturing. At the lower end of the cañon the stream makes a turn and leaves the ridge very obliquely, exposing regularly stratified and thin bedded sandstones and shale. The former contains poorly preserved fossils among which were specimens of *Aucella*. The Golden Gate series with green eruptives forms a prominent hill just north of the creek, and here the strata stand vertical and strike 70 degrees west of north. The Knoxville beds outcrop 400 feet below this exposure and directly in line with the strike of the former rocks. The strike of the Knoxville beds is however directly at right angles to that of the Golden Gate series; they dip away at an angle of 50 degrees, the inclination gradually becoming less down the creek. The exposures close to the contact are not good, but are however sufficient to show that there has been considerable movement. Lenticular masses of serpentine occupy the contact in places.

On the south side of the creek, and nearly opposite this place, the road has been graded around a knob of green eruptive. The Knoxville sandstones surround it on three sides and appear in the bank above the road, lying directly over the eruptive mass. The bedding is nearly flat while no trace of metamorphism is to be seen.

The relations shown in this vicinity are most conclusive of a non-conformity. The regular even bedding of the Knoxville beds, which show no traces of shearing except near the contact, is in most marked contrast with the irregular stratification of the older rocks. A careful search in the latter for fossils revealed only a few indistinct plant remains.

The two formations were followed to the southeast, for a number of miles, but here, as almost everywhere else in the Coast ranges, the stratigraphical relations have been masked

by shearing along the contact, a condition due to an upward movement of the basement rocks forming the axes of the mountains. Lava flows and intrusives are abundant in the older rocks and. with the exception of the serpentine, are absent from the Knoxville.

MOUNT DIABLO.

Turner* has well described the metamorphic rocks of mount Diablo, but does not state the relation of the Knoxville to them. Neither does he express a definite opinion of the relative ages of the Knoxville and diabase which is so extensively developed on the northwest of the metamorphic area.

On Bagley creek the writer has noted the Knoxville in direct contact with a gabbro-like rock, but there has been so much shearing that the relation is not clear, although it is evident that the shales near the contact are not metamorphosed.

On the northeast side of the mountain the Knoxville beds are in contact with the "metamorphic rocks" (Golden Gate series), but the exposures are not good. As in other parts of the Coast ranges, the Knoxville shows a regular and even bedding, and dips away at varying angles from the core of older rocks. The soft strata of the former result in smooth, rounded slopes, while, in sharp contrast, rise the hard and more or less silicified sandstones, jaspers and eruptives of the Golden Gate series.

An examination of the large diabase "massif" has convinced the writer that it is older than the Knoxville, which lies on three sides of it. Although the two could not be found in actual contact, because of the clayey nature of the Knoxville, the latter appears at no point to show the slightest alteration due to contact with an eruptive mass. In Mitchell cañon the shales are traced to within 200 feet of the contact, and it is certain that if the diabase were really intrusive the metamorphism would have resulted in rocks weathering less readily. An additional fact reported by Turner is that the diabase contains inclusions of the metamorphic rocks, indicating its intrusion into them, while inclusions of the Knoxville are absent.

There can be no question that on mount Diablo we have the Golden Gate series with associated eruptives antedating the

*Bull. Geol. Soc. Am., vol. II, p. 385.

Knoxville and separated from it by the same marked non-conformity so conspicuous in other parts of the Coast ranges.

During this trip to mount Diablo with Mr. F. M. Anderson the latter discovered the first fossils reported from the "metamorphic rocks" of this locality.

Owing to the failure of the fauna and flora yet found in the Golden Gate series to throw any certain light upon the question as to whether it is Cretaceous or Jurassic, it seems that the main dependence will have to be placed on stratigraphy.

The fossils indicate that it is very probably not older than the upper Jurassic, while the recognition of the important non-conformity separating it from the Knoxville, either throws the series into the Jurassic or necessitates the reconstruction of the Cretaceous.

THE GALENA AND MAQUOKETA SERIES.

By F. W. SARDESON, Minneapolis, Minnesota.

Part I.

The names Galena series and Maquoketa series are used here to designate the geologic formations that have been called Trenton group and Hudson River group in the states of Minnesota, Iowa, Wisconsin and Illinois. The same are nearly the equivalent formations to the typical Trenton and Hudson (Hudson River) groups or series of New York.

The aim in using this local terminology instead of the names Trenton and Hudson is to obviate introducing the question of exact relationship with the type series of New York, and to enable the Galena (Trenton) and Maquoketa (Hudson) series to be thereby more easily correlated, the one exposure with another, within their respective areas. It will be easier to define the probable application of the names Trenton series and Hudson series after having defined the Galena and the Maquoketa series than before it. As it now is, the terms Trenton and Hudson are not constant in each of the states within the area in question, but include now more and now less, and this inconsistent fluctuation in value is so great as to seemingly prove that the true correlation with the type formations has not yet been accomplished. Under such circumstances it seems to the writer most advisable to use

only the local names. the definition of which has been verified through type exposures existing within the area itself.

As said, the Galena and Maquoketa series are not uniformly and consistently defined in each state, nor even in different counties of the same state, but varying limits are assigned to them. Some time ago the writer tried to outline a more uniform and more detailed classification of the Galena and Maquoketa series than before existed,* but the same work remains in part to be completed. After having made considerable further investigation it is now intended to advance again in the same direction, and since the publications that have in the meantime surveyed the same ground more or less completely have by no means shortened the way, but on the contrary have placed the beginning a little back from the point before reached, we will act accordingly.

In this discussion there will be considered, first of all, the classifications by authors generally, and tables of synonomy for each division and subdivision will be given, after which a better classification will be outlined.

The Galena series and the Maquoketa series are very favorable for exact division and delimitation and for correlation of one exposure with another, because the strata are relatively horizontal and quite undisturbed, because fossil remains are numerous, often well preserved and accessible, and because the division and subdivision are guided by many lithologic differences. The subdivisions are, moreover, nearly all coextensive and often constant in original thickness. All taken together are not over 450 feet thick, and several beds may be found in single exposures. It is possible, therefore, as it is also necessary, to combine stratigraphic, paleontologic, and lithologic evidence to work out the relations to each other of the parts of these two series. The reason why greater uniformity in classification has not obtained is found apparently less in the nature of the formations than in the custom of limiting research to the bounds of states and counties. Both the series and their subdivisions being traceable continuously from Minnesota through Iowa to Illinois and Wisconsin, one system of division and of nomenclature would have been the inevitable result of wider investigation by each author. But, in the man-

*Bull. Minn. Acad. Nat. Sci., vol. III, p. 319 (1892).

ner in which the research has been divided, certain special phenomena have had undue influence upon the results. Authors have based the classifications in a one-sided manner upon the lithologic characters, and, since local alterations in the rock often exceed the original differences, mistakes have resulted.

Neither the Maquoketa nor the Galena series consists wholly of limestone except locally. The Galena series is limestone in its southern (Illinois) extent, but towards the north it includes shales and clays. The Maquoketa series is mainly limestone and dolomite in the north (Minnesota) but becomes gradually shale and clay southward. Both together consist, nevertheless, of a series of beds that are divided from one another by lithologic and paleontologic differences. Very natural division lines obtain, and some of these have been chosen by authors in every case as the limits for the formations and beds they have deemed worthy of designation, but, unfortunately, not everywhere have they chosen the same. Even where the intention has been to maintain a prior classification the divisional zones have been mistaken, because, owing to both original differences and local alterations of lithologic characters, the same beds are not everywhere alike nor separated by like contrasts.

A brief outline of the divisions and the names of them, according to different classifications in each state is shown in the following diagram; but there is omitted from it the classification by N. H. Winchell and E. O. Ulrich* which is essentially a repetition of an earlier classification that is included in this discussion. The "special designations" used in the same volume are for the present omitted since their discussion would be very detailed and really unnecessary. Palpable errors are also not tabulated.

Synonymy of Terms.

In the following tables of synonymy the older of the two series, the Galena, is given first, then its divisions and subdivisions in the order of sequence, after which the Maquoketa series in like manner.

*Geol. of Minn., final report, vol. 3, pt. 1, p. L.

Illinois.		Wisconsin.			Iowa.		Minnesota.					
Cincinnati group, limestones and shales.		Blue and green shales or Hudson River group, or Cincinnati group.			Hudson River group or Maquoketa shales.		Galena.			Hudson River group	Cincinnati limestones and shales.	14
						Galena limestone.		Galena.				13
												12
												11
Trenton limestone group.	Galena limestone.	Galena limestone.			Galena limestone.	Trenton limestone.						10
							Trenton limestone.	Upper Trenton limestone.	Galena.	Galena limstone.	Trenton limestones and shales.	9
												8
									Upper Trenton l.			7
										Trenton shales.		6
	Blue limestone or "Trenton proper."	Trenton limestone.	Blue limestone or "Trenton proper."	Upper Blue bed.	Trenton limestone.			Green shales.				5
				Upper Buff bed.								4
				Lower Blue Bed.								3
												2
	Buff limestone.		Buff limestone or Lower Buff bed.					Lower Trenton or Trenton limestone.				1

GALENA SERIES.

Lower Cliff limestone or lead-bearing limestone, D. D. Owen, (1844). Rep. on Exploration of Iowa, Wisconsin, and Illinois; p. 32.

Chazy, Birds-eye, and Trenton limestones (undivided), Charles Whittlesey (1851). Geology of Lake Superior, Land District: p. 175.

Trenton limestone group, James Hall (1861). Geology of Wisconsin, vol. I, p. 31.

Trenton Group, A. H. Worthen (1866). Geological Survey of Illinois, rep. vol. I, p. 141.

Trenton Group, C. A. White, (1870). Geology of Iowa, vol. I, p. 174.

Trenton Limestone, Frank H. Bradley, (1870). Geological Survey of Illinois, vol. IV, p. 201.

Trenton Limestones, James Shaw, (1873). Geological Survey of Illinois, rep. vol. V, p. 66: Trenton formation, loc. cit., p. 86: Trenton Group, loc, cit., p. 111.

Trenton limestone, A. H. Worthen, (1873). Geological Survey of Illinois, rep. vol. V, p. 279.

Trenton Group, C. Rominger, (1873). Geological Survey of Michigan, rep. vol. I, part III, p. 56.

Trenton Limestone, N. H. Winchell, (1876). Fourth Annual Report Geological and Natural History Survey of Minnesota, p. 42.

Trenton Group, T. C. Chamberlin, (1877). Geology of Wisconsin, vol. II, p. 290.

Trenton limestone, A. H. Worthen, (1883). Geological Survey of Illinois, rep. vol. VII, p. 40.

Rocks of the Trenton Period, N. H. Winchell, (1884). Geological and Natural History Survey of Minnesota, Final Report, vol. I, p. (249) 339.

Rocks of the Trenton Period (part), N. H. Winchell, (1888). Geological and Natural History Survey of Minnesota, Final Report, vol. II, p. 39.

Trenton Group, F. W. Sardeson, (1892). Bulletin Minnesota Academy of Natural Sciences, vol. III, p. 325.

Trenton limestones and shales, C. W. Hall and F. W. Sardeson (1892). Bulletin of the Geological Society of America, vol. III, p. 356.

Galena-Trenton limestones. W. H. Norton, (1893). Iowa Geological Survey Ann. Rep., vol. II, p. 178.

Trenton, Samuel Calvin (1895). Iowa, etc., vol. 4, pp. 73, 91.

Divisions of this Galena series have been made with considerable variation by different authors in different states. But the division line which has been most uniformly followed is that between the "Trenton" or Lower Trenton and the Galena. The latter formation rather than the former is probably equivalent to the Trenton limestone of New York. Confusion will be avoided therefore, by using a new local term, Beloit formation, and the local term Galena for these two divisions.

BELOIT FORMATION.

Blue limestone, D. D. Owen, (1844). Rep. on Exploration of Iowa, Wisconsin, and Illinois, p. 19.

Chazy, Birds-Eye, Black River and Trenton limestones, James Hall, (1851). Geology of the Lake Superior Land District, p. 140.

Trenton limestone, James Hall, (1858). Geology of Iowa, vol. I, p. 54.

Trenton or Blue limestone, J. D. Whitney, (1858). Geology of Iowa, vol. I, p. 341.

Trenton limestone, H. C. Freeman, (1868). Geological Survey of Illinois, rep. vol. I, p. 276.

Trenton limestone, C. A. White, (1870). Geology of Iowa, vol. I, p. 174.

Trenton limestone, T. C. Chamberlin, (1877). Geology of Wisconsin, vol. II, p. 290.

Trenton limestone, R. D. Irving, (1877). Geology of Wisconsin, vol. II, p. 588.

Trenton (Buff and Blue) limestones, Moses Strong, (1877). Geology of Wisconsin, vol. II, p. 680.

Trenton, or Buff and Blue limestone, Moses Strong, (1883). Geology of Wisconsin, vol. IV, p. 88.

Trenton (Blue and Buff) limestone, T. C. Chamberlin, (1883). Geology of Wisconsin, vol. IV, p. 412.

Trenton, F. W. Sardeson (1892). Bulletin Minnesota Academy of Natural Sciences, vol. III, p. 325.

Trenton, C. W. Hall and F. W. Sardeson, (1892). Bulletin Geological Society of America, vol. III, p. 356.

Trenton limestone, W J McGee, (1891). Eleventh Annual Report U. S. Geological Survey, p. 329.

Trenton limestone, Chas. R. Keyes, (1893). Geological Survey of Iowa. First Annual Report, p. 24.

An old subdivision of the "Trenton" or Beloit formation is into a lower portion, Buff limestone and upper or Blue limestone. The synonomy of the lower divison is as follows:

BUFF LIMESTONE.

Buff-colored limestone, John Locke, (1844). Owen's Report on Iowa, Wisconsin, and Illinois, p. 154.

Calciferous rock, I. A. Lapham, (1851). Geology Lake Superior Land District, p. 169.

Buff limestone, James Hall, (1861). Geology of Wisconsin, vol. I, p. 33.

Buff limestone, J. D. Whitney, (1861). Geology of Wisconsin, vol. I, p. 157. Quarry rock, (of same), plate VI.

Buff limestone, A. H. Worthen, (1866). Geological Survey of Illinois, rep. vol. I, p. 141.

Buff limestone, J. D. Whitney, (1866). Geological Survey of Illinois, rep. vol. I, pl. 4, ante p. 162; p. 165.

Buff limestone, James Shaw, (1873). Geological Survey of Illinois, rep. vol. V, p. 28, 66, 86, 111, 129.

Lower Buff Beds, T. C. Chamberlin, (1877). Geology of Wisconsin, vol. II, p. 293.

Buff limestone, ("Quarry rock"), T. C. Chamberlin, (1883). Geology of Wisconsin, vol. IV, p. 413.

Lower Buff limestone, T. C. Chamberlin, (1883). Geology of Wisconsin, vol. I, p. 162.

Buff bed, F. W. Sardeson, (1892). Bulletin Minnesota Academy of Natural Sciences, vol. III, p. 325.

Buff limestone, C. W. Hall and F. W. Sardeson, (1892). Bulletin Geological Society of America, vol. III, p. 360.

Co-ordinate with the Buff limestone, an upper and larger division was formerly recognized.

"BLUE LIMESTONE."

Blue Fossiliferous limestone, John Locke, (1844). Owen's Report on Iowa, Wisconsin, and Illinois, p. 153.

Blue or Trenton limestone, I. A. Lapham, (1851). Geology Lake Superior Land District.

Blue limestone, James Hall, (1861). Geology of Wisconsin, vol. I, p. 35.

Blue limestone-Trenton limestone, J. D. Whitney, (1861). Geology of Wisconsin, vol. I, p. 162.

Blue limestone or Trenton limestone, J. D. Whitney, (1866). Geological Survey of Illinois, vol. I, p. 166.

Blue limestone or Trenton limestone, James Shaw, (1873). Geological Survey of Illinois, rep. vol. V, pp. 21, 38, 66, 86, 99, 111, 129.

Blue limestone, T. C. Chamberlin, (1883). Geology of Wisconsin, vol. IV, p. 413.

This limestone has been subdivided into three beds more nearly uniform with the Buff limestone. Beginning as before, with the lowest, we have the

LOWER BLUE LIMESTONE.

Glass Rock and Upper Pipe Clay Opening, J. D. Whitney, (1861). Geology of Wisconsin, vol. I, p. 254, pl. VI.

Lower Blue Beds, T. C. Chamberlin, (1877). Geology of Wisconsin, vol. II, p. 295.

"Glass rock," T. C. Chamberlin, (1883). Geology of Wisconsin, vol. IV, p. 413.

Lower Blue limestone, T. C. Chamberlin, (1883). Geology of Wisconsin. vol. I, p. 162.

"Buff limestone," E. O. Ulrich, (1886). Fourteenth Annual Report Geological and Natural History Survey of Minnesota, p. 57.

UPPER BUFF LIMESTONES,

Brown rock, J. D. Whitney, (1861). Geology of Wisconsin, vol. I. p. 253, pl. VI.

Upper Buff beds, T. C. Chamberlin, (1877). Geology of Wisconsin, vol. II, p. 295.

"Brown rock," T. C. Chamberlin, (1883). Geology of Wisconsin, vol. IV, p. 412.

Upper Buff limestone, T. C. Chamberlin, (1883). Geology of Wisconsin, vol. I, p. 163.

UPPER BLUE LIMESTONE.

Green rock, J. D. Whitney, (1861). Geology of Wisconsin, vol. I, p. 252, plate VI.

Upper Blue beds, T. C. Chamberlin, (1877). Geology of Wisconsin, vol. II, p. 296.

"Green rock," T. C. Chamberlin, (1883). Geology of Wisconsin, vol. IV, p. 412.

Upper Blue limestone. T. C. Chamberlin, (1883). Geology of Wisconsin, vol. I, p. 163.

A different division of Trenton was used in the Minnesota Geological Survey reports. For example, the strata comprising the "Trenton" or Beloit formation were divided into two nearly equal parts, and the lower half, containing the Buff limestone and part of the Lower Blue limestone, were called the Lower Trenton Limestone, the remainder of the formation, Green Shales. These, with the Upper Trenton Limestone and sometimes a division called Galena Limestone, make up the Galena-Trenton series.

Later the term Trenton limestone was used instead of Lower Trenton, and a division of Trenton Shales was made to include the Green Shales and part of the true Galena.

LOWER TRENTON LIMESTONE OR TRENTON LIMESTONE.

Lower Trenton limestone, N. H. Winchell, (1876). Geological and Natural History Survey of Minnesota, 4th Annual Report, p. 42.

Lower Trenton limestone, N. H. Winchell, (1877). Geological and Natural History Survey of Minnesota, 5th Annual Report, pp. 147, 148.

Trenton limestone, N. H. Winchell, (1888). Geological and Natural History Survey of Minnesota, Final Report, vol. II, pp. 10 (39), 70, 288, 356, 388.

Trenton limestone beds, C. W. Hall, (1889). Bulletin Minnesota Academy of Natural Sciences, vol. III. No. 1, p. 113.

GREEN SHALES.

Green Shales, N. H. Winchell, (1876). Geological and Natural History Survey of Minnesota, 4th Annual Report, p. 42.

Green Shales, N. H. Winchell, (1877). Geological and Natural History Survey of Minnesota, 5th Annual Report, p. 147.

Green Shales, N. H. Winchell (1884). Geological and Natural History Survey of Minnesota, Final Report, vol. I, p. 218. (Hudson River Shales), 293, 334.

Green Shales, N. H. Winchell (1888). Geological and Natural History Survey of Minnesota, Final Report, vol. II, p. 40.

TRENTON SHALES.

Trenton shales, E. O. Ulrich (1883). Geological and Natural History Survey of Minnesota, 14th Annual Report, p. 57.

Trenton Shales, N. H. Winchell (1888). Geological and Natural History Survey of Minnesota, Final Report, vol. II, p. 288, 356.

This term Trenton Shales ought perhaps to be treated as a synonym for Green Shales, which it is in general, although the application of the term makes it include more strata than under the old term.

The Galena series has also been divided into two parts in a different manner from the above, and the first division, under the name Trenton, contained the Lower Trenton, Green Shales and Upper Trenton, and the second was called Galena. Although the division was probably intended to be the same as that in Iowa and Wisconsin under the same name, it is so much different that a separate heading is required.

"TRENTON."

Trenton limestone, N. H. Winchell (1873). Geological and Natural History Survey of Minnesota, 1st Annual Report, p. 92.

Trenton limestone, M. W. Harrington (1876). Geological and Natural History Survey of Minnesota, 4th Annual Report, p. 90, 111.

Trenton limestone, N. H. Winchell (1877). Geological and Natural History Survey of Minnesota, 5th Annual Report, p. 25 and 147.

Trenton limestone, N. H. Winchell (1884). Geological and Natural History Survey of Minnesota, Final Report, vol. I, p. 370.

The term Galena, as used co-ordinate with this last extension of the term Trenton, includes only the upper part of the Galena proper.

"GALENA."

Galena limestone, N. H. Winchell (1874). Geological and Natural History Survey of Minnesota, 1st Annual Report, p. 104.

Galena limestone, M. W. Harrington (1876). Geological and Natural History Survey of Minnesota, 4th Annual Report, p. 91.

Galena formation, N. H. Winchell (1884). Geological and Natural History Survey of Minnesota, Final Report, vol. I, p. 334. 371.

In one instance the term Upper Trenton is used to include the Galena exclusive of the "Galena" as given above.

Upper Trenton, N. H. Winchell (1884). Geological and Natural History Survey of Minnesota, Final Report, vol. I, p. 334.

Except as just described, the division of the Galena formation has not been attempted until very recently. And it seems possible that the separation into "Upper Trenton," as given, and "Galena" was due to mistake and that the intention was to make the same division in Minnesota as in Iowa and Wisconsin.

The Galena formation, as a grand division of the Galena-Trenton series and co-ordinate with the Beloit or "Trenton"

limestone series, is found to have been described under the following:

GALENA FORMATION.

Galena limestone, I. A. Lapham (1851). Geology of the Lake Superior Land District, p. 169.

Galena limestone, James Hall (1851). Geology of the Lake Superior Land District, p. 291.

Galena limestone, James Hall (1858). Geology of Iowa, vol. I, part 1, p. 60.

Galena limestone, J. D. Whitney (1858). Geology of Iowa, vol. I, part 1, p. 350.

Galena limestone, James Hall (1861). Geology of Wisconsin, vol. I, p. 43.

Galena limestone, J. D. Whitney (1861). Geology of Wisconsin, vol. I, p. 168.

Galena limestone, A. H. Worthen (1866). Geological Survey of Illinois, rep. vol. I, p. 141.

Galena limestone, J. D. Whitney (1866). Geological Survey of Illinois, rep. vol. I, p. 169.

Galena limestone, C. A. White (1870). Geology of Iowa, vol. I, p. 176.

Galena limestone, James Shaw (1873). Geological Survey of Illinois, rep. vol. V, p. 17, 36, 66, 76, 86, 99, 111, 129, 154.

Upper Trenton limestone, N. H. Winchell (1876). Geological and Natural History Survey of Minnesota, 4th Annual Report, p. 42.

Upper Trenton limestone, N. H. Winchell (1877). Geological and Natural History Survey of Minnesota. 5th Annual Report, p. 147.

Galena limestone, T. C. Chamberlin (1877). Geology of Wisconsin, vol. II, p. 305.

Galena limestone, R. D. Irving (1877). Geology of Wisconsin, vol. II, p. 562.

Galena limestone, Moses Strong (1877). Geology of Wisconsin, vol. II, p. 683.

Galena limestone, Moses Strong (1883). Geology of Wisconsin, vol. IV, p. 90.

Galena limestone, T. C. Chamberlin (1883). Geology of Wisconsin, vol. IV, p. 407.

Galena (dolomite), T. C. Chamberlin (1883). Geology of Wisconsin, vol. I, p. 165.

Upper Trenton limestone, N. H. Winchell (1884). Geological and Natural History Survey of Minnesota, Final Report, vol. I, p. 290, 293.

Upper Trenton limestone, N. H. Winchell (1888). Geological and Natural History Survey of Minnesota, Final Report, vol. II, p. 39.

Galena limestone, W J McGee (1891). Annual Report, United States Geological Survey, p. 327.

Galena limestone, Chas. R. Keyes (1893). Iowa Geological Survey, 1st Annual Report, p. 25.

The Galena limestone has been locally made to include some strata that contain a fauna different from that of the Galena series and which form apparently a transition bed. Most often in Illinois and eastern Wisconsin the base of the "Cincinnati" or "Hudson River group" is not known. But in northwestern Illinois and adjacent parts of Wisconsin and Iowa the demarkation has been made above the transition bed just mentioned. There has not, however, been uniformity even with the same author evidently in this demarkation. In southeastern Minnesota this transition shale and limestone bed has been included in the upper series. The above synonymy of each series is given in general without discrimination in this respect. The discussion of the matter will be given later.

MAQUOKETA SERIES.

Hudson River group, James Hall (1851). Geology of the Lake Superior Land District, p. 148.

Hudson River group, or Blue Limestone and Marls (of Ohio), Charles Whittlesey (1851). Geology of the Lake Superior Land District, p. 174.

Blue Shales, James. G. Perceval (1855) and (1856). Annual Report, Geological Survey of Wisconsin.

Hudson River group, James Hall (1858). Geology of Iowa, vol. I, part I, p. 64.

Hudson River Group, J. D. Whitney (1858). Geology of Iowa, vol. I, part 1, p. 356.

Green and Blue Shales and Limestones, James Hall (1861). Geology of Wisconsin, vol. I, p. 47.

Hudson River Group, J. D. Whitney (1861). Geology of Wisconsin, vol. I, p. 177.

Cincinnati Group, A. H. Worthen (1866). Geological Survey of Illinois. rep. vol. I, p. 137.

Cincinnati Group, J. D. Whitney (1866). Geological Survey of Illinois, rep. vol. I, p. 175.

Cincinnati Group, A. H. Worthen (1868). Geological Survey of Illinois, rep. vol. III, p. 26.

Maquoketa Shales of the Cincinnati Group, C. A. White (1870). Geology of Iowa, vol. I, p. 180.

Cincinnati Group, F. H. Bradley (1870). Geological Survey of Illinois, rep. vol. IV, p. 200, 216, 233.

Cincinnati Group (or Shales), James Shaw (1873). Geological Survey of Illinois, rep. vol. V, p. 16, 35, 65, 77, 99, 110, 131, 152.

Hudson River or Cincinnati Group, C. Rominger (1873). Geological Survey of Michigan, rep. vol. I, part 3, p. 50.

Galena limestone, N. H. Winchell (1876). 4th Annual Report, Geological and Natural History Survey of Minnesota, p. 49 (includes some Devonian by error).

Cincinnati Shales and Limestone, T. C. Chamberlin (1877). Geology of Wisconsin, vol. II, p. 314.

Cincinnati Group, Moses Strong (1877). Geology of Wisconsin, vol. II, p. 685.

Hudson River (Cincinnati) Shales and Limestone, T. C. Chamberlin (1883). Geology of Wisconsin, vol. I, p. 170.

Cincinnati Group, F. W. Sardeson (1892). Bulletin, Minnesota Academy of Natural Sciences, vol. III, No. 3, p. 325.

Cincinnati Limestones and Shales, C. W. Hall and F. W. Sardeson (1892). Bulletin, Geological Society of America, vol. III, p. 365.

Maquoketa Shales, W J McGee (1891). 11th Annual Report, United States Geological Survey, p. 326.

Maquoketa Shales, Chas. R. Keyes (1893). 1st Annual Report, Iowa Geological Survey, p. 14.

Maquoketa Shales, W. H. Norton (1893). 2d Annual Report Iowa Geological Survey, p. 177, pars.

The lower two-thirds of the Maquoketa have been sometimes clearly described as Galena.

Galena limestone, N. H. Winchell (1884). Geological and Natural History Survey of Minnesota, Final Report, vol. I, p. 290, 297.

Galena limestone, N. H. Winchell (1888). Geological and Natural History Survey of Minnesota, Final Report, vol. II, p. 41.

Galena, Samuel Calvin (1895). 4th Annual Report, Iowa Geological Survey p. 80, 92.

Conclusion.

The classification of the Galena and Maquoketa series is easily seen to be lacking in uniformity, both in respect to division and to nomenclature throughout their extent. According to strict rules of priority, essentially that classification which has been and is recognized in Wisconsin should be valid in all four states and all counties where the Galena and Maquoketa series are found. Indeed, that fact seems to have been nearly always recognized, or, at least for no other apparent reason, that nomenclature is used in classifications where even a different basis of subdivision is followed.

There is, however, in each of the other classifications that are in the above diagram a basis of truth, and their deviations are founded upon existing characters, whose meaning ought to be expressed in any general uniform classification of these series. To the Wisconsin classification, which will need to be but little corrected, should be added data derived from the others, as well as some data not expressed in any. Practically

all of the divisional lines that have been selected by different authors for different localities can and ought to be recognized. There should even be added one or two more in order to express more nearly the true relations of the strata of the two series to each other. Such a classification will be the subject of the next paper.

ORIGIN OF THE HIGH TERRACE DEPOSITS OF THE MONONGAHELA RIVER.*

By I. C. White, Morgantown, W. Va.

At the Minneapolis meeting of the A. A. A. S., in 1883, the writer presented a paper before Section E in explanation of the terrace deposits along the Monongahela river, as well as those along the old and abandoned Teazes valley, which extends from the Great Kanawha at St. Albans, along the C. & O. R. R. to the Ohio river at Guyandotte.

In that paper the origin of these deposits was referred to the hypothetical glacial dam in the region of Cincinnati, evidence for the existence of which had just then been published by Prof. G. F. Wright, of Oberlin, Ohio.

Continued studies of the river between the Great Kanawha and the Monongahela have still led the writer to refer the terrace deposits of the latter river to a glacial dam, but not to the one which Prof. Wright believes existed at Cincinnati.

It is now pretty surely established, through the work of Carll, Spencer, Hice. Foshay, Chamberlin, Leverett, and others. that the Monongahela, lower Allegheny, and upper Ohio waters drained northward into the lake Erie basin in pre-glacial time. The great ice-field which covered northern Ohio and Pennsylvania, and descended southward nearly to the Ohio river at Rochester, or Beaver, Pa., would, of course, effectually stop the northward drainage of this pre-glacial river, and impound the accumulating water into a vast lake-like reservoir, until it filled up to the level of any divides that might lead the surplus water across them to other drainage channels.

If any such old outlets exist, they would furnish almost a demonstration of the reality of this supposed glacial lake,

*A "G. S. A." paper, read before Section E. of "A. A. A. S.," at the Buffalo meeting, August, 1896.

which I have named lake Monongahela. The writer has often called the attention of geologists to a remarkable old gap in the divide which now separates the Ohio and Monongahela waters, at the head of the latter stream, just west of Salem, on the Baltimore and Ohio Southwestern R. R., thirty-six miles west from Grafton. It is a valley 300 to 400 feet wide, filled with clay deposits, and separating Ten Mile creek, on the Monongahela side, from Middle Island creek waters of the Ohio drainage. The summit of this coll, one mile west of Salem, is 1,102 feet, A. T., while the bottom of the cut through it on the railroad or bed-rock under the clay-covered summit, is 1,081 feet, A. T.

At the head of Rock Camp creek, another tributary of Ten Mile creek, which heads several miles (8 to 10 miles) north of Salem, there is another gap through the divide at exactly 1,143 feet, A. T., as determined by an experimental R. R. survey. Also, Prof. T. M. Jackson informs me that there is a third gap through the same divide, one mile north from the one on the Baltimore & Ohio R. R., and through this the North West turnpike passes.

The general elevation of the divide which separates the waters of Ten Mile and Middle Island creeks is 1,400 feet to 1,500 feet, A. T. Here, then, are three gashes or wiers cut down 300 feet below the general level into valleys of considerable breadth from whose level summits the waters now go in opposite directions.

The escape of the impounded water of lake Monongahela would sufficiently account for these old channels or colls. Curiously enough, there is another outlet at this same level (1,100 A. T.) near the head waters of the West Fork of the Monongahela, since the wide level summit at Arnold's, on the West Virginia and Pittsburgh R. R., is 1,095 feet, A. T., and the railroad is cut five to six feet below the level stretch of land which makes the divide between the Monongahela and Little Kenawha waters. This 1,100 foot divide at three or four different outlets from lake Monongahela, could hardly be a coincidence merely, but must represent the old colls through which the surplus water of the imprisoned rivers escaped to lower levels during glacial times.

We thus have at hand an explanation of the immense deposits of stratified silts, clays, boulder beds, and other trash found at the junction of streams all along the Monongahela river, and especially above the level of the upper slopes of the river gorge, beginning at one hundred to one hundred and fifty feet above the present river.

A large stream, Decker's creek, joins the Monongahela at Morgantown, coming in from the east after cutting through Chestnut ridge and draining a large mountain area east from the latter. At its junction with the Monongahela it has dumped large deposits of sand, boulders, and clay, which after much erosion still retain, in favorable localities, a depth of seventy feet. From this fact, and also because these deposits were first studied there, I have named them the Morgantown beds, confining the name to the deposits which rest on the preglacial rock-floor of the river. These beds, which are often as distinctly stratified as the under-lying Coal Measure rocks, can be found wherever any shelf of the ancient rock-floor of the river has been preserved, from the head of the Monongahela to Pittsburg, and on northwestward along the Ohio, and up the Beaver until they are met and submerged by the vast deposits of the terminal moraine. About one mile north from Morgantown, and near the Flats school-house, these beds contain beautifully preserved fossil plants imbedded in a bluish gray pottery clay of impalpable fineness. The plant bed lies at an elevation of 240 feet above the present river, or about 1,030 feet A. T.

The small collection that I made of these plants and deposited in the West Virginia University, several years ago, together with collections made at different times by Prof. S. B. Brown, of the University, and also some collected by Mr. Walter Hough, of the National Museum, were all sent to Dr. F. H. Knowlton, the accomplished paleobotanist of the U. S. National Museum, Washington, D. C., for identification. Under date of Sept. 17th, 1895, Dr. Knowlton sent me the following account of these fossils:

Report on a Collection of Fossil Plants from Morgantown, West Virginia.

By F. H. Knowlton, Ph. D.

Some years ago I was informed by Dr. Walter Hough of the U. S. National Museum of the existence of finely preserved fossil leaves in the

vicinity of Morgantown, W. Va. A few small fragments were brought to the Museum by Dr. Hough, but it was not until 1894 that a collection of any magnitude was obtained. These proved to be of so much interest that the collection in the West Virginia University has also, by the kindness of S. B. Brown, professor of geology, been placed at my disposal. This material has all been made use of in the following examination.

The study of these plants has not been quite completed, but enough has been done to transmit the following presentation. A few well preserved examples appear to be new to science or at least not readily identifiable with known forms.

Thus far ten forms have been determined with much certainty as follows:

1. *Eqnisetum arvense* L.

A small fragment of a sterile branch.

This species is distributed from Virginia to California and northward to Greenland, and is also found in Europe. It is very abundant and attains perhaps its maximum development in New England.

2. *Cyperus sp.*

There are a number of stems that belong evidently to some cyperaceous plant, but they are too fragmentary to be determined.

3. *Potamogeton robbinsii* Oakes.

There are a great number of fragments of stems and leaves of this species, all so well preserved as to leave no doubt as to the correctness of their identification. Its present distribution is from New Brunswick to New Jersey, north of lake Superior and northward.

4. *Liquidambar styracifolia* L.

A number of fruiting heads and leaves are referred to this species. Its present distribution is from Connecticut and Illinois to Florida and Texas.

5. *Platanus occidentalis* L. *Sycamore.*

Several fruiting heads are referred to this species. It is found from Maine to Vermont, south.

6. *Ulmus racemosa* Thomas. *The White Elm.*

A well preserved leaf is referred to this species. It is now found from Ontario and Vermont to Missouri and Kentucky. It is nowhere very common, but is most abundant at the north.

7. *Quercus falcata* Mich.

Two finely preserved leaves of this species. It is found from Long Island to Florida.

8. *Betula nigra* L. *Black Birch.*

There are several leaves of this species all perfectly preserved. The tree is now distributed from Massachusetts to Florida.

9. *Fagus ferruginea* Ait. *Beech.*

A large number of well preserved leaves are referred without hesitation to this species. It is a common tree from Nova Scotia to Florida and west.

10. *Castanea pumila* Mill. *Chinquapin.*

A single leaf only is referred to this form. It now grows commonly from Pennsylvania to Florida and west to Indiana and Texas.

The species thus far determined all belong to living species. Some of them enjoy a wide distribution and are still found growing in the region, while others are now only found to the north. One in particular, *Potamogeton robbinsii*, is confined to the north.

It seems probable from the evidence of the plants that they were pushed down from the north during the ice invasion and were entombed, while the species has retreated again to the colder area.

The occurrence of *Potamogeton robbinsii* in these beds is of special interest, since it practically demonstrates that there was during Glacial times a movement of water from the edge of the ice near Beaver, Pa., southward along the Monongahela valley through the escape wiers just described, which brought with it this northern plant. It is possible that a systematic search would bring to light many other such northern forms, as well as throw much light upon the slight changes that have taken place in species since the Glacial epoch, because there can be little doubt that these plants were embedded in their present matrix during the Ice age The particular locality in which the plants occur is near the head waters of two little streams which rise against each other, and then flowing north, empty into the Monongahela, their mouths being two and one-half miles apart.

The broad level summit between the heads of the two streams is covered with the clay deposits up to 251 feet above the present river bed, and at one locality (Mr. Baker's well) they have a thickness of 65 feet. The surrounding hills are made up of the soft shales of the Barren or Elk River coal measures, and it is in just such a sheltered bayou back from the main channel of the river that we would expect to find such deposits in lake Monongahela.

A fine quality of clay for common blue stoneware, or crockery, is always found among these deposits where any considerable stream empties into the Monongahela from the west (soft rock areas), while sand and boulders predominate at the mouths of those streams draining from the east (mountain or sand-rock areas). The celebrated pottery clays of Geneva and Greensboro, Pa., just north from the West Virginia-Pennsylvania line are deposited opposite the mouth of Dunkard creek, a stream entering the Monongahela from the west, and drain-

ing quite a large area of Permian shales. Here the following structure is exposed at the clay diggings back of Geneva in descending to the Monongahela river:

1. Rounded boulders, sand, and river trash	50 ft.
2. Soil, boulders, etc., to top of clay bed	5 ft.
3. Reddish clay, fine, tough	10 ft.
4. Clay mixed with sand, and brown iron ore	6 ft.
5. Bluish gray clay, fine, tough	10 ft.
6. Bed-rock to level of Monongahela river	140 ft.

The elevation of low water here is 772 feet A. T. so that the rock floor of the old river is now 912 feet A. T.

The same kind of clay as that at Greensboro and Geneva, and which occurs at 150 feet above the river on the Millan farm, West Morgantown, was analyzed by Dr. De Roode, chemist of the U. S. Agricultural Experiment Station at Morgantown. W. Va., with the following results:

Silica	65.95
Alumina	20.23
Oxides of iron	3.17
Lime	0.32
Magnesia	1.36
Soda	0.53
Potash	2.60
Water and loss	5.84
Total	100.00

At Morgantown, sixteen miles above Geneva, the level of the old rock floor at the head of High street is 916 feet A. T. or 129 feet above river level, and the same at the University buildings, which are situated on top of this old river channel. But on the west side of the river, at Keck's hill, where the deposit is 70 feet thick, the level of the old floor is only 905 feet A. T. This difference between Morgantown and Geneva is to be explained because of the soft shale floor of the old channel at Morgantown, which was eroded deeper than the hard sandstone of the old channel at Geneva.

At Uffington, three and one-half miles above Morgantown, near the mouth of Booth's creek, we find the level of the old floor on the hard Mahoning sandstone under a large deposit of sand (brought out of the mountains from the east by Booth's creek), at 915 A. T., or 125 feet above the present bed.

Fairmont and Palatine at the junction of the Tygart's valley and West Fork rivers, 26 miles above Morgantown, are situated on the wide plain excavated by the pre-glacial river, and as might be expected, the old rock floor is covered to a great depth with terrace deposits, consisting of sand, rounded boulders, etc., from the Tygart's valley, and pottery clays from the West Fork river. The elevation of the old rock-floor is 972.5 feet A. T., or 122 feet above the present river, while the top of these deposits extends up to 1,067 feet A. T.

The terrace material at Fairmont has been well exposed along Fairmont avenue, and its stratified condition is well shown. At the Smith & McKinney building the excavation showed the different stratified layers of sand and clay dipping about 10° to the west.

A layer of clay, about eight feet thick, at near 1,000 feet A. T., has long been mined for pottery clay, in the Fairmont region. The corresponding bed at Morgantown has an elevation of 945 feet A. T.

At Clarksburg, thirty miles above Fairmont, the West Fork river is joined by a large tributary, Elk creek, and the two streams had carved out a wide valley in pre-glacial time, whose rock-floor under the city has an elevation of 986 feet A. T., or about 70 feet above low water (916 feet A. T.) at the junction of Elk and the West Fork rivers. Here a great deposit of clays and quick-sand, twenty-five feet thick, covers all the level surfaces up to 1,020 feet A. T. There are some layers of rather coarse sand in the deposits, but the clays predominate, and they are found all along the West Fork river, and its tributaries from Fairmont to Clarksburg and on beyond to Weston, thirty miles south, where they extend to only about thirty feet (1,020 feet A. T.) above water level (990 feet A. T.).

At Grafton, on the Tygart's valley river, twenty-two miles above Fairmont, the elevation of the top of the railroad pier in the river is 997 feet and the terrace deposits extend only about twenty-five feet higher.

The principal town sites along the Monongahela river from Weston to Pittsburg, viz: Weston, Clarksburg, Grafton, Monongah, Fairmont, Palatine, Montana, Morgantown, Point Marion, Geneva, Greensboro, Rice's Landing, Fredericktown,

Brownsville, Belle Vernon, Charleroi, Monongahela, Elizabeth, McKeesport, Braddock, Homestead, all have their upper and more level portions situated on the ancient floor of the pre-glacial valley. It is this wide and almost level area of deposits, stretching from Braddock to the Monongahela, across to the Allegheny river via Homestead, and East Liberty, which forms the principal site of Pittsburg itself, as well as Allegheny, beyond. Here a remnant of this ancient valley floor is appropriately named Monument hill, rising, as in does, like an island between the present mouth of the Allegheny river and its filled-up and more ancient channel just north of the island. The bed rock under the terrace deposits of Monument hill is now 190 feet above low water or 890 feet above tide, and the rock floor under the vast terrace deposits at Bellevue, still further down the Ohio river comes at the same elevation, while the summit of the same deposit there, as well as in Pittsburg and Allegheny, has nowhere been observed above 990 feet A. T., or 290 feet above low water in the present rivers.

This old elevated valley floor can be followed down the Ohio river to Rochester, and up the Beaver river past New Brighton, Beaver Falls, Rock Point, Wampum, Mahoningtown, and New Castle, beyond which, up the Shenango, it sinks out of sight under the drift-filled valleys, and at Sharon is submerged by 60 feet of cover, 40 feet below the present water level, or 780 feet A. T.

The exact course of the pre-glacial river from Sharon northwestward to the lake Erie basin has not yet been clearly delineated, but Mr. Leverett's studies leave little doubt that from Sharon the course was northwestward through the low drift-filled divide at Warren, O., (now only 900 feet A. T., and its rock floor probably 200 feet lower), and thence northward along the general course of Grand river.

Just how long lake Monongahela existed, and drained its surplus waters southward through the Middle Island and Little Kanawha gateways, cannot be estimated except by the deposits just described; but finally the barrier along the upper Ohio, (probably at the "narrows" below Moundsville, W. Va., as believed by Profs. Chamberlin and Leverett) gave way, and the level of lake Monongahela was speedily lowered by the rapid cutting away of the soft rocks along the present Ohio

valley. Just how much of Ohio river history dates from this interglacial origin, it is yet impossible to determine, but the character of the topography along the river, everywhere between Rochester, Pa., and Cincinnati, O., (below which the writer has not studied it), would lead to the conclusion that all this portion of the river is new, and that the conclusions of Prof. Tight, of Denison University, Granville, O., are well maintained, viz: that in pre-glacial times the waters of the Muskingum, Scioto, and other rivers of Ohio, all flowed northward into the lake Erie system.

This being true, it would follow as a corollary that all of the West Virginia rivers which rise on the western slope of the Allegheny mountain-divide, including the Little and Big Kanawhas, and the Big Sandy, must have once gone northward in pre-glacial times and joined the Scioto, Muskingum, and other Ohio streams in their northward course, right athwart the present valley of the Ohio, but on a plane probably 200 to 300 feet above the present rock floor of the Ohio. The search for these former high level valleys north from the Ohio, as bisected by it, is reserved for a future chapter, and it is possible that therein may be found an explanation of the old and abandoned high level Teazes valley, which does not admit of the explanation suggested by Prof. William M. Davis, in a recent number of "Science," viz: stream piracy of Coal river by the Great Kanawha, because the old valley in question is filled with transported boulders and gravel that could have come only from the crystalline rocks of the Blue Ridge in Virginia, and hence the Kanawha itself must once have flowed along Teazes valley, and been captured by another stream which led it northward to the newly cut Ohio valley, at Point Pleasant.

If the conclusions here inferred could be fully sustained by further study of the Ohio river system, it will be readily perceived that a pre-glacial drainage map of Pennsylvania, Ohio, West Virginia, and Kentucky would bear very little resemblance to a map of the present drainage, for if the Monongahela, Lower and Upper Allegheny once went northward into the lake Erie basin, there can be no doubt that the Upper Susquehanna also took this northward route to the sea, in pre-glacial times, and that much of its present course through Penn-

sylvania is new. The resultant modifications which such a change of direction in a great river system must necessarily bring to pre-existing drainage lines. are so varied and amazing even in contemplation, that their study must furnish many problems of surpassing interest to topographers of the modern school, so ably typified by Prof. Davis and his work.

he following table represents the descent of the ancient Monongahela river toward the lake region for a portion of its course between Weston, W. Va., and Sharon, Pa., as well as the present water levels between the same points, and also the highest levels of the Morgantown beds, where known:

Miles		Present river, A. T.	Ancient river, A. T.	Top of Deposits, A. T.
0	Weston	990	1,000	1,030
40	Clarksburg	916	986	1,020
75	Fairmont.........	851	973	1,067
101	Morgantown	787	916	1,038
117	Geneva	772	912	1,022
206	Pittsburg.........	700	890	990
332	Rochester.........	662	865	....
237	Beaver Falls......	715	860	....
246	Rock Point........	740	840	....
257	New Castle.......	780	825	....
278	Sharon............	840	780	....

This table shows that while the present river falls 290 feet between Weston and Pittsburg, the floor of the ancient stream descended only 110 betwen the same points, or only about one-half foot per mile, which is practically that of a base-leveled valley, or one quite advanced in age, to say the least. The rapid descent of the modern river below the old rock floor of the ancient one gives rise to the steep slopes and gorge-like character of the Monongahela valley everywhere between Weston and Pittsburg, while the same is true of the lower courses of all the larger tributary streams, the descent in these being very rapid in the last few miles of their courses, while in their upper reaches the slope is gentle and the topography much older looking.

The smaller streams, which rise only five to ten miles back from the Monongahela, descend to it in the last mile or two of their courses by a series of rapids and cascades, while the still smaller brooks and rivulets have cut more notches in the bounding valley walls below the level of the ancient rock floor

of the Monongahela, so that every feature of the topography tends to confirm the conclusion that the age of the river below the old base-leveled plain shown in the table, has been of comparative short duration, and must be measured by only a few thousand years at most.

The writer had intended to present a map with this paper, showing in a crude way the pre-glacial drainage of the areas herein described, but so much detailed work must yet be done before any approach to accuracy can be hoped for that the mapping is left for other and more skillful workers in this promising field. In this connection I would call the attention of students of the subject to the former northward course of the Little Beaver and the Slippery Rock.

The former once went northward along with the Monongahela drainage, but being dammed up by the northern ice it cut a new channel about fifteen miles long, southward into the Ohio river drainage, and this fully accounts for the wonderful change in topography along the lower portion of its course, as well as for the southward transportation of large granite boulders several miles beyond the limits of true glacial movement, thus giving rise to the phenomena called the "fringe" by Lewis and Wright; for wherever a stream was thus impounded the blocks of ice floating southward across these temporary lakes from the terminus of the glacier would of course bear away and, melting, scatter over the surface many masses of imbedded rock.

The Slippery Rock now joins the Connoquenessing in a curious manner, by meeting it direct, and the combined stream turns off at right angles to enter the Beaver at Rock Point. In pre-glacial time the Slippery Rock left its present channel a short distance above Kennedy's upper mill, and following the present valley of Big run, turned northwestward near New Castle, and cutting squarely across the present gorge of the Neshannock (which is also of post-glacial origin) passed two and one-half miles north of New Castle and entered the ancient Monongahela near Harbor Bridge. All this is fully attested by the wide drift buried valley, which can be followed from Slippery Rock clear through to the Shenango, and the course of this ancient stream also confirms the conclusion of Leverett that the pre-glacial drainage took the Shenango

route via Sharon instead of the Mahoning, and that the lower portion of the latter stream is of recent origin. The Slippery Rock was turned southward at Kennedy's upper mill by the advancing ice-sheet which filled its pre-glacial valley, and on retreating left a dam of drift 100 feet high across its former course, while the wild gorge and raging stream between Kennedy's mill and the Connoquenessing, so different from the wide valley and sluggish current above the mill, though the outcropping rocks are the same, fully attest the recent origin of the twenty-mile cut between the mill and the Connoquenessing, near Wirtemburg.

EVIDENCE OF THE FORMER EXTENSION OF GLACIAL ACTION ON THE WEST COAST OF GREENLAND AND IN LABRADOR AND BAFFIN LAND.

By George H. Barton, Boston, Mass.

The Sixth Peary Expedition to northern Greenland, in the summer of 1896, carried two outside and independent parties, one from Cornell University under the direction of Prof. R. S. Tarr, and one from the Massachusetts Institute of Technology under the direction of Prof. Alfred E. Burton. Of the latter party the writer was a member.

Sailing from Sydney, Cape Breton, July 16, on the steam whaler "Hope," a fine vessel for work in the ice, the first icebergs were encountered at the northern entrance to the Strait of Belle Isle on the 18th, and on the 19th pan-ice was encountered, which was found in more or less abundance as far north as Cumberland sound, the entrance to which was so completely filled with it that no passage could be found. Stops were made at Turnavik, on the coast of Labrador, at various points in Hudson strait along its north shore, and on Big Savage island; and then, after a vain attempt to enter Cumberland sound, a direct run was made across Davis strait. The Greenland coast was first sighted some distance south of Disko bay, about lat. 67°. A short stop was made at Godhaven, at Sarkak, which is at the head of Disko bay, then passing through the Waigat, with a brief visit to the mainland when about half way through, and around the end of Nugsuak peninsula, the Institute party were landed, on the morning of August 5, at

the little settlement of Umanak, on an island in the large Umanak fiord, lat. 70° 40′. From this as a base extended trips were made by boat to the head of Karajak fiord, where the two Karajak glaciers were studied in detail, as well as some of the smaller ones, and brief observations made upon all along this fiord, and also to the head of Itivdliarsuk fiord, where brief observations were made upon the several glaciers there. From Karajak fiord visits were made to the edge of the inland ice in two places, and a single trip was made upon its surface inland to a distance of perhaps fifteen miles beyond the nearest exposed land. Returning to Umanak, the party was taken on board the "Hope" on its return from the north, on September 9; and after brief stops along the Nugsauk peninsula and at Godhaven, sailed direct for Cumberland sound, off which ice was again encountered which caused a delay of two days before entrance could be made to the sound. Two days were then spent in visits to Niantilik and Black Lead island. The latter place was left on Sept. 19, no ice was met with and but few bergs, and Sydney was reached on Sept. 26, with all the members of the various parties in good health.

Evidences of former extension of glacial action. At Turnavik, on the Labrador coast, the whole country is well rounded to the highest summits, giving fine *roches moutonnées* in many instances. Striæ are well preserved for some distance above sea-level, but weathering has caused them to disappear from the higher elevations. Furrows are numerous at all elevations, some of which are strongly curved, in direction. The motion of the former ice-sheet was about northeast, nearly normal to the coast line. Erratics are rare, if not entirely wanting, the few boulders present seeming to be due to local decomposition.

The coastal area of Labrador, from Turnavik to cape Chidley, as seen from the vessel, has, in general, the rounded appearance of a glaciated region. In the vicinity of cape Mugford, lat. 58° 30′, Table hill, White Bear island, and the Kig-la-pait mountains, 2,000 feet high, all appearance of rounding is lost when seen directly off shore, and only sharp peaks or serrated edges are seen, giving the impression that the country here has never been overridden by an ice-sheet.

However, when seen from farther south, in a direction transverse to the direction of the ice-motion, if it passed toward the sea, rounded outlines are sufficiently distinct to justify the conclusion that probably the ice did override this as well as the other portions of the Labrador coast.

At Big Savage island, on the north side of Hudson strait, lying off the south shore of Meta Incognita, the southeastern part of Baffin land, the summits are well rounded and a moraine lies directly upon the highest point above Ashe inlet, at a hight of 250 feet above sea. There were also observed here a large series of elevated beaches which were carefully studied by members of the Cornell party. The erratics here are of the same type as the underlying gneiss, with the exception of scattering fragments of a limestone that we did not find *in situ*.

On the mainland of Meta Incognita the general rounding is very pronounced, the motion of the ice having been nearly, or quite, parallel to Hudson strait, and passing outward toward Davis strait. The underlying rock here is a coarsely banded, highly garnetiferous gneiss, containing many beds of a coarsely crystalline limestone. The erratics are of the same rocks as those below, except occasional small fragments of a fine grained limestone or dolomite, similar to those on Big island.

In Cumberland sound, on the south side, at Black Lead island and Niantilik, there is the same general rounding, though the surface of the rock is highly disintegrated and very rough, retaining no appearance of glaciation except upon the large scale. Here also the motion of the ice was toward Davis strait. Erratics are very numerous here, much more so than at other places on the west side of Davis strait.

On the east or Greenland side of Davis strait, Disko island was the most southern point visited. At the south end of the island directly back of Godhavn. the cliffs are very precipitous, rising at once to a hight of more than 2,000 feet. As seen from one of the higher summits at this southern margin, the upper surface of Disko presents the appearance of an old peneplain with rounded domes and some sharp peaks rising above the general level. The rounded domes are apparently covered by local ice-caps while the sharper peaks carry only narrow areas of ice in their small valleys. In this part of the

island there is no complete ice-cap, but several small ones. These send down tongues through all the valleys descending to the sea, as described by Chamberlin.* Gneiss is the basal rock here, but is not seen far above sea-level, the upper portions being entirely basaltic. Erratics of gneiss are numerous, however, to the highest levels, which would imply that farther inland the gneiss rises to the upper surface of the island as suggested by Chamberlin, or, as I am inclined to think, that during a former extension of the main continental ice-cap of Greenland these erratics were transported across the Waigat. Time did not allow the investigation of this problem at Disko, but evidence of the former extension of the Greenland ice-cap in the Umanak region has caused the serious consideration of this possibility. The Waigat separates the island of Disko from the Nugsuak peninsula. This peninsula is one of the largest extending outward from the west coast of Greenland. It is bordered nearly all around with precipitous cliffs, in some places nearly vertical, which rise almost directly to about two thousand feet, and not far inland are peaks reaching from four thousand to six thousand three hundred, the highest point as given on the chart of the British Admiralty. The highest elevation reached here at Ekaluit, near the northeast end of the peninsula, is about 3,000 feet above the sea, and from this place eastward several points from 1,000 to 2,000 feet were visited.

The peninsula, like the island of Disko, has its own local ice-caps, but unconnected, as far as seen, with the main ice-cap of the continent. From this a succession of tongues pass downward through very many of the valleys of the northeastern side, a few entering the sea, but the greater number stopping at some little distance above sea-level. With two apparent exceptions they all show evidence of comparatively recent diminution. The highest points visited present well rounded outlines of typical *roche moutonnée* form, and striæ are found nearly everywhere.

The motion of ice here was approximately parallel to the Karajak fiord, which bounds it on the northeast, and outward toward Baffin's bay. The higher peaks, seen from a distance, are more angular, but most of them present some appearance

*Journal of Geology, vol. II, p. 771.

of a steeper slope on the west and a more gentle slope on the east. The Ekaluit valley contains no glacier in the main valley, but the valleys tributary to it on the south nearly all have glacial tongues descending directly from the ice-cap. These all show evidence of diminution so far as visited. The main valley has well defined lateral moraines of an extinct glacier on its southern side, which have been cut through by the streams from the present lateral valley glaciers to a depth of about forty feet without reaching the bed rock below.

On the nunatak, between the Great and Little Karajak glaciers, at the head of Karajak fiord, the highest point, given on the chart as 1,260 feet above the sea, but in reality much higher, presents a series of most typical *roches moutonnées*, with motion about parallel to the fiord, as before. On the peninsula of Anat, northwest of the Itivdliarsuk glacier, very fine *roches moutonnées* occur on the highest point, about 3,100 feet above the sea, with the motion parallel to that before mentioned. Erratics are numerous over all the region surrounding the Karajak and Itivdliarsuk fiords, consisting principally of gneiss, which is the underlying rock of this whole region. On Anat, however, large numbers of limestone boulders occur, with also many of a sandstone closely like the Triassic of the Connecticut valley. These do not occur *in situ* outside of the ice-cap and must underlie it somewhere inland.

Old lateral moraines occur along the mountain sides at various elevations above the present level of the Great and Little Karajak and Itivdliarsuk glaciers, indicating the former greater volume of these. A small valley cutting across the southern corner of Anat, the bottom of which in its upper portion has about the same elevation as the present surface of the Itivdliarsuk glacier, contains lateral moraines, showing that this glacier once sent a tongue down this valley to the sea, making a nunatak of the extreme south point of Anat. At various places along the sides of the Karajak and Itivdliarsuk fiords, at an elevation of perhaps 500 feet, are well defined lateral moraines. These are especially well shown on the islands of Umanak and Ikerasak, at the foot of the peak on each island. These peaks rise almost vertically above the rounding of the main mass of the islands to elevations of 3,100 and 2,500 feet, respectively, both presenting sharply an-

gular forms and sharp serrated peaks. It is evident that at one stage of the ice-sheet these were nunataks rising above the level of the ice, which is now approximately represented by the position of the lateral moraines.

From the above evidence it seems clear that in this part of Greenland, at least, the continental ice-cap once extended far beyond its present limits. Whether, in its extreme extension, it passed beyond the limits of the outer headlands into the broad waters of Baffin's bay, I have not sufficient data to judge; nor from the limited area studied during the five weeks can any legitimate conclusions be drawn for other portions of the coast north or south of the Umanak region.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Elements of Geology: A text-book for Colleges and for the General Reader. By JOSEPH LE CONTE. Fourth Edition, revised and enlarged, with new plates and illustrations. (New York. D. Appleton and Co., 1896.) The well-known author of this popular work has rendered geology, and especially American geology, a service by revising it and incorporating in this edition some of the results of more recent investigations. It is to-day probably the best known of American geological text-books, and the improvements impressed on this edition will tend to keep it in the lecture rooms and libraries of most American geologists.

The entire book is divided into three parts, viz: Dynamical Geology. Structural Geology, and Historical Geology, in the order named, which is natural and logical. Under Dynamical Geology the treatment of volcanoes, geysers and earthquakes is full, perhaps unreasonably full, for a text-book on geology, although these agents are among the most interesting and powerful of geological history. There is here, and in the discussion of the action of glaciers, a series of "graphic" illustrations, some of which, after the clear enunciation of the facts and the principles involved. do not add to the clearness of the text, but are, instead, even embarrassing. For instance, after the paragraph on p. 47, on "Motion of Glaciers." which is clear, simple and comprehensible, one might ask: what is the need of the "Graphic Illustration" of the same movement given on page 48, which involves the study of a diagram with its lettering and its lining, its ordinates and co-ordinates? To many readers it is an unpleasant obstacle, as it gives nothing new, and is more time-consuming and difficult of understanding than the simple summary statement of the paragraph that precedes it. In general, however, the illustrations, though not of first-class execution and quality, are important aids to the text.

It is, of course, difficult, in a revision of an old text-book, to amplify it equally, and bring it up to date in all directions without the substantial creation of a new work. One might wish that the author had taken the time to make such a new work. It is needed, in the light of recent great progress, and the antiquated condition of some of the views advocated by the text of this. Perhaps it is impossible for a single author to compass the whole science of modern geology without seriously compromising and belittling some departments. Perhaps it is necessary that some such method shall be pursued as that recently adopted by Eastman in respect to modern paleontology, i. e., assign the parts to specialists, with freedom to incorporate the latest, well authenticated, classification and the most advanced views. The text before us suffers materially in consequence of the non-comprehension of some of the important fields of recent research in American geology. The magnificent results of the U. S. Geological survey, and of several of the state surveys, brought out mostly since the last edition of this text-book, are but slightly reflected from its pages, one might almost say entirely overlooked. This is particularly apparent in the treatment of the Archean and the lowest paleozoic. It is not necessary to specify. This makes the work less adapted to the northern states where the vigorous and advanced schools of geological science are mostly located, since these rocks are specially prominent in the northern parts of the United States and in Canada.

The common view of the origin of anthracite by metamorphism of bituminous coal is given; the exceptions and modifications, and the inadequacy of this view are pointed out, but nothing is said of Stevenson's theory of the origin of anthracite which was published several years ago, and which eliminates these difficulties. The author also repeats the old and insufficient notion of the old edition as to the origin of iron ore, making it a result of organic acids acting on the rocks that contained it in disseminated state. "Therefore we conclude that both *now* and *always* iron ore is, and has been, accumulated by organic agency." This is the sole cause mentioned. On the contrary, that several well authenticated sources of iron ore are admitted by most geologists is very certain. In the lake Superior region are very extensive deposits of titanic magnetite embraced entirely in the gabbro, and they must have been genetically connected with the gabbro, which is of igneous origin. The decay of basic silicates, and the concentration of their iron in suitable basins is a well-known process of iron formation, much dwelt on by J. P. Kimball.

The author writes interestingly and forcibly on many general geological topics. That is one of the excellencies of the volume. Its summaries are often terse and yet lucid: witness his definition of the Permian in America, p. 426, or the discussion of the interior of the earth, pp. 86-88, and, in general, the presentation of the phenomena and cause of the Glacial epoch.

The phenomena of the Quaternary period, whose cause is presumed to have been fluctuations of level in the high latitude portions of North

America, are divided between the Glacial epoch and the Champlain epoch. The elevation is said to have been from 1,000 to 3,000 feet above the present hight. During the Champlain epoch there was a downward motion of the same regions until the sea stood 500 to 1,000 feet above its present position. These movements and their effects on the lakes and rivers, as well as on the drift deposits, are skillfully grouped. The author allows for two advances of the ice, with a long interglacial epoch, and shows the differences between this history in eastern North America and the same on the Pacific side. On this subject the author's presentation shows a familiarity with the latest literature. With the exception, perhaps, of the descriptions of the animal life of the Tertiary, this chapter is the most satisfactory of the volume.

The whole work is built on the theory of evolution, organic and inorganic, and goes so far as to accept, with some caution, Pithecanthropus erectus as the veritable "missing link" between man and the apes.

The work well fills the place it is proposed to fill, viz., intermediate between a manual filled with details, suitable for reference by the investigator, and an elementary treatise. This middle ground is where are found most of the students of geology in America. N. H. W.

Geological Survey of Canada, Annual Report (*new series*), *volume VII, 1894.* G. M. DAWSON, Director. Pages 1206, with eleven maps, and fifteen plates and diagrams. (Ottawa, 1896. Price, $1.50.) This volume consists of eight reports, separately paged and designated successively by the letters A, B, C, F, J, M, R, and S. The first report, a summary of the work of the survey during 1894, and the second, a report on the area of the Kamloops map-sheet, in British Columbia, both by the director, have been noticed, respectively, in the AMERICAN GEOLOGIST for September, 1895, and May, 1896; and the sixth, by ROBERT CHALMERS, on the surface geology of an area including parts of New Brunswick, Nova Scotia, and Prince Edward island, was reviewed in this magazine for last July.

Report C, by R. G. McCONNELL, on an exploration of the Finlay and Omenica rivers, head streams of the Peace river, comprises 40 pages, with two plates and a sketch map. The rocks of this district, in ascending stratigraphic order, are Archean gneisses and schists named the Shuswap series; slates, quartzites, and conglomerates, probably referable to the Lower and Middle Cambrian, having a thickness of about 4,000 feet; a great limestone formation, corresponding to the Castle Mountain group of the Bow River section; the higher Banff limestones of Devonian and Carboniferous age: volcanic schists, probably Upper Paleozoic; shales and limestone, shown by fossils to be Triassic; conglomerate and sandstones, probably Cretaceous: Upper Laramie conglomerates, shales, and sandstones, containing plant remains; and Glacial deposits of boulder-clay, gravels, sands, and silts. Gold was first discovered in these drift gravels in 1862, and the yield of the scanty placer mining to the present time has probably exceeded a million dollars.

Report F, by D. B. DOWLING, is noted elsewhere in this number.

Report J, in 157 pages, with a map, is by R. W. ELLS, on a portion of the Province of Quebec comprised in the southwest sheet of the "Eastern Townships" map (Montreal sheet), with a chapter by FRANK D. ADAMS, on the Laurentian north of the St. Lawrence river. The formations range in age from Laurentian to Devonian, with thick deposits of glacial and modified drift, and, on the great plain of the St. Lawrence, marine Champlain clays and sand. In an appendix (pages 113-157J), HENRY M. AMI gives preliminary lists of the organic remains in the bed rocks of this area, from the Potsdam sandstone to the Devonian.

Report R, of the section of Chemistry and Mineralogy, by G. CHRISTIAN HOFFMANN, comprises 68 pages; and the report (S) of Mineral Statistics and Mines, for 1893 and 1894, by E. D. INGALL and H. P. H. BRUMELL, 187 pages. The total mineral production of Canada is tabulated as $21,000,000, very nearly, for each of these years. Gold, silver, lead, asbestos, gypsum, coal, and petroleum, increased in the amount and value produced: while copper, iron ore, mineral water, natural gas, salt, and pottery, decreased. The production of nickel increased from four million to five million pounds, approximately, but with a decrease of its aggregate value. W. U.

The Formation of the Quaternary Deposits of Missouri. By JAMES E. TODD. (Missouri Geological Survey, vol. x, pp. 111-217, with plates xii-xxii, and figures 20-24 in the text; 1896.) Glacial drift is mapped as covering the northern two-fifths of the state, mainly extending south to the Missouri river, but leaving an unglaciated tract several miles wide next north of the Missouri and west of the Mississippi to distances of about ninety miles above their confluence. In the central part of the state, however, the glacial drift extends across the Missouri river along a distance of nearly seventy-five miles. Loess, high terraces, and alluvium, are mapped and described along the Missouri river and in the Mississippi valley southward to the vicinity of St. Louis; but the present report does not treat of the contemporaneous residuary and alluvial deposits of the more southern part of Missouri, nor of the loess and other Quaternary formations along the Mississippi south of St. Louis.

The till, weathered to a yellowish brown color near the surface, but having a leaden blue color below, usually holds only few boulders and smaller rock fragments; but nearly everywhere it contains some from remote sources, namely, the crystalline rocks of Canada and Minnesota. In certain localities Prof. Todd finds all the rock fragments to be apparently of remote northern origin. Near the north line of Missouri, the till sometimes is almost 200 feet thick; but southward it rarely exceeds 40 feet, and is frequently less than five feet. Indeed, over considerable areas it exists only in small and shallow patches. It thus ceases toward the margin of the drift, which usually comprises nothing more than sparsely scattered boulders. Glacial striæ are found well preserved on the limestone strata near St. Joseph, in Kansas City, and in other localities, occurring almost at the extreme limit of the drift.

Professor Todd well describes the deep trough-like valleys or gorges of the Missouri and Mississippi rivers, with numerous cross-sections, and discusses the Quaternary changes and evolution of these great streams.

Correlating the Missouri glacial drift with that of the states farther north, he notes the changing conditions of the Kansan, Aftonian, Iowan, and Wisconsin stages or epochs, as named by Chamberlin: and he ascribes the snow and ice accumulation mainly to high uplift of northeastern portions of the continent. He thinks, however, that the ice-sheet, although extending into Missouri, did not reach quite to the limits of the drift and striæ, which, on the border, are attributed to floes and bergs. W. U.

The Production of Iron Ores in 1895. By JOHN BIRKINBINE. (Extract from the Seventeenth Annual Report of the United States Geological Survey, pp. 1-27, 5 maps. Washington, 1896.) This paper, which will form the first portion of Part III of the 17th annual report, has just appeared in pamphlet form. Michigan held first place in 1895 with a production of 5,812,444 tons. Minnesota stood second, with a total of 3,866,453 tons. Alabama was third, with 2,199,390 tons to her credit, and Pennsylvania, Virginia, Wisconsin, Tennessee, New York and New Jersey followed in the order named, no one of them having produced as much as a million tons and their combined output being less than that of Minnesota. The iron ore production of the Lake Superior region in 1895 was 10,268,978 tons or 62.31 per cent. of the output of the entire country. This is more than double the maximum output of the Bilbao district in Spain, and the average quality is not equalled by any other large producing district. Sketch maps showing the location of the active mines on the five Lake Superior ranges, and brief accounts of the conditions obtaining on each of them add to the value and interest of the report.

Special attention is paid to the Mesabi iron range, and the Minnesota Geological Survey is congratulated "upon having pointed to the region now known as the Mesabi range as a probable iron ore producing district prior to active explorations." The estimated amount of iron ore that this new range (which in 1895 produced 27.6 per cent. of the Lake Superior output) can furnish is put at the very moderate total of 200 million tons. The average tonnage value of Minnesota iron ore at the mines was only $0.73 as against an average value of $1.45 for Michigan and $1.14 for the whole country. On the other hand, the average iron content of Minnesota ore is not less than 62 per cent., while that of the country at large is about 54 per cent., and "the phosphorus in non-bessemer Mesabi ores is below that of the average non-bessemer ores of the country."

Foreign ores imported into the United States in 1895 amounted to 524,153 tons with a total value of $786,207.

In comparing these figures with those given by the Iron Trade Review and other authorities it should be remembered that these are data of actual production at the mines and other figures are usually those of

rail and lake shipments. The former will generally be somewhat in excess of the latter for any given year, although they will not vary much over a period of years. H. V. W.

Report on the Country in the Vicinity of Red Lake and part of the Basin of Berens River, Keewatin. By D. B. DOWLING. (Geol. Survey of Canada, Ann. Rept., n. s., vol. 7, pp. 1F-54F, one map, 1896.) This paper presents a report of explorations in an area of 6,300 square miles lying east of lake Winnipeg and north of Rainy lake; more accurately it is situated between latitude 50 degrees 30 minutes and 51 degrees 50 minutes N., and longitude 92 degrees 40 minutes and 94 degrees 15 minutes W. of Greenwich. The geological formations, except the drift, are all pre-Cambrian in age and are mapped as Laurentian and Huronian. Under the former term are included granites, gneisses and some mica schists. The exact relation of the Laurentian to the Huronian is not fully stated, although one might infer that the former was intrusive into the latter; at any rate several areas of granite mapped as Laurentian are clearly intrusive into the Huronian. The Huronian consists of schists of various kinds, limestones, altered basic and acid igneous rocks, agglomerates and conglomerates.

In general it may be said that the rocks and their relations so far as known are similar to those of the closely adjoining Lake of the Woods and Rainy Lake regions, which were described a few years ago by Dr. A. C. Lawson, and it seems most probable that the area here described by Mr. Dowling is the same in age and general relationships as the region reported on by Dr. Lawson. Some of the rocks here classed as Laurentian (mica schists) would probably have been put in the Coutchiching by Dr. Lawson, but Mr. Dowling states that other strata most resembling the typical Coutchiching are only highly altered parts of the Huronian in contact with the Laurentian eruptives. The author questions the propriety of extending the name Keewatin to the rocks he describes as Huronian, although this would seem to be the most natural thing to do.

The presence of a conglomerate holding jasper pebbles is of interest as indicating a possible division of the rocks here mapped as Huronian into two unconformable series, a division which has already been worked out in strata of the same general age on the south side of lake Superior by Prof. Van Hise and which also exists in similar rocks in Minnesota north of lake Superior. U. S. G.

The Physical Features of Missouri. By CURTIS FLETCHER MARBUT. (Reports of the Missouri Geological Survey, vol. x, pp. 11-109, with eleven plates, and nineteen figures in the text; 1896.) This a very interesting and satisfactory description of the contour of Missouri, with discussion of the epeirogenic movements and cycles of subaerial erosion to which the form of the surface is due. The general upland, in its two parts named the Prairie region and the Ozark region, is a peneplain or graded surface cutting across the bevelled edges of the strata. Its altitude is mainly between 800 and 1,500 feet above the sea. The uplift

from lower altitudes, at which Cretaceous and early Tertiary baselevelling of this peneplain took place, is referred to some stage in the middle or later part of the Tertiary era, previous to the Lafayette period. Since that differential uplift, which gave the present long and gradual slopes of the upland areas, the rivers have channelled their meandering valleys, which vary in size up to a width of several miles and in depth from 100 to 500 feet. Much additional examination of the river courses is needed, however, to explain many of their minor features and their detailed history. W. U.

On the Existence of Pre-Cambrian and Post-Ordovician Trap Dikes in the Adirondacks. By H. P. CUSHING. (Trans. N. Y. Acad. Sci., vol. 15, pp. 248-252, Sept., 1896.) From recent work in New York state, chiefly in Clinton county, Prof. Cushing has become convinced that there were two periods of intrusion of dike rocks in the Adirondack region, instead of one period as formerly thought. This is an interesting point in the history of the Adirondacks and in the study of these dikes, for our knowledge of which we are chiefly indebted to Profs. Kemp and Marsters. Prof. Cushing presents in brief the evidence for the separation of these dikes into two series, and concludes that one series followed the dynamic metamorphism of the gneiss, limestone and gabbro series of the Adirondacks, but antedated the Potsdam sandstone. The typical rocks of these dikes are diabases. The second series cuts all the strata up to and including the Utica shale, and the dike rocks are "trachyte" (bostonite) and basic rocks, mostly camptonites and monchiquites. U. S. G.

Structural Details in the Green Mountain Region and in Eastern New York. By T. NELSON DALE. (U. S. Geol. Survey, 16th Ann. Rept., pt. I, pp. 543-570, 1896.) The author has collected in this paper excellent illustrations and brief descriptions of various structural details which he has observed in his work in the Green mountains. The phenomena illustrated are folds of several varieties, false bedding, obscuration of bedding by cleavage, cleavage, cleavage banding, stretching, etc. These illustrations from the note book of a geologist working in a crumpled and metamorphic area are of much interest, and show on a small scale many important details of structure, details which the worker in such an area must be continually searching for. U. S. G.

A Handbook of Rocks, for use without the microscope. J. F. KEMP. Printed for the author. New York, 1896, roy. oct. 176 pp. This is a general elementary treatise on rocks, the design being to furnish a compendium for teachers, based mainly on American rocks and literature. Its author has traversed essentially an untrodden field, in bringing American petrography together into a systematized form, and grouping the facts in a reasonable scheme of modern classification. He has thus rendered American geology a great service. In doing this he has left signs of his route all along his course, and anyone can follow and amplify his work. These signs are the constant references to American literature which are massed in connection with the chemical analyses

given, which, in itself, is a great service to the petrographer. These references of course are to all sorts of petrographical literature, but the book itself, in its treatment, involves only those characters which can be apprehended without the microscope. The glossary, embracing mining and petrological terms, also gives the names of many rocks that have been defined in America. N. H. W.

Determinative Mineralogy and Blowpipe Analysis (BRUSH). Revised and enlarged by S. L. PENFIELD. New York, John Wiley and Sons 1896. Oct., pp. 108. Price $3.50. Every American chemist and mineralogist knows well the excellencies of "Brush's Determative Mineralogy," for it has been in their laboratories for more than twenty years, and in constant use. This revision by Penfield, an expert and enthusiastic mineralogist, has, *mirabile dictu*, increased its value. The chief change consists in the infusion of more chemistry into the treatment of the subject. There is a short introductory chapter which concisely sets forth the fundamental principles of the chemical nomenclature and combinations which are involved in the methods and in the tables. It is also noticeable that throughout the work, excepting in the tables, which are the same as in the last edition, there is considerable enlargement. N. H. W.

CORRESPONDENCE.

THE ICE-SHEET IN GLACIAL NARRAGANSETT BAY. Owing to my not seeing proof of my paper on "The Retreat of the Ice-Sheet in the Narragansett Bay region," the following important features of the Barrington stage were not discussed in the proper place (see pages 150-168).

Evidence was cited on p. 156 to show that in the case of the Greenwich Cove stage there was a change of water-level before the ice disappeared from the head of the cove. To be exact, the water-level fell off from a hight at least 50 ft. above present sea-level to or below the existing marine limit.

A renewed study of the Barrington sand-plain made with my colleague, Mr. T. A. Jaggar, Jr., shows that it, too, has a drainage crease "springing out of the air," on the northern border as if from the vanished ice-sheet, and terminating on the southern margin in a fan heading between two lobes of the delta front. This fan spreads out in the swampy foreground of the clay field and is of the subaerial type. As in the Greenwich Cove stage, we have here again evidence of the deposition of a delta-like sand-plain with the water as high as 50 ft. above the present sea-level; the next recorded event is the formation of a subaerial fan whose base is near or at the present sea-level. This fan is known to be contemporaneous with the ice remnant at the head of the completed sand-plain, because the crease marks the path of drainage out of the ice, across the plain, and on to the fan.

I have already given reasons for considering the Barrington stage later than the Greenwich Cove stage. If these stages were contempo-

raneous these changes of level might be considered as marking a single episode in the epeirogenic movements of the region and their bearing on water-level might be dismissed as pointing to no definite conclusion. The, it seems to me, satisfactory evidence of the repetition of like changes of level accompanying similar glacio-aqueous conditions points clearly to the nature of the oscillations of water-level in Glacial Narragansett bay.

If these two cases may be accepted as the basis of a statement regarding this water-level, it would seem that times of high water were times of maximum sand-plain construction; that immediately following these episodes and before the marginal ice entirely disappeared, the water-level fell away 50 ft. or more.

These changes of level are analogous to those of our large inland rivers, and come under the head of flood changes. Ice dams in Glacial Narragansett bay appear incapable of affording an explanation. Only so far as floating ice may have served to form barriers by gorging in narrow passages in the lower bay can ice help in explaining the drainage features of these two sand-plain stages. I find myself driven in consequence of these phenomena to adopt a view similar to that which the elder Dana set forth in regard to the upper limit of river border formations, "There is no direct relation to the level of the ocean. They were made by flooded rivers or lakes; and the hight of the flood-waters determined their level" (Man. Geol., third ed., 1880, p. 551). The difficulties in the way of accounting for the pitch of the upper surface of the waters in this glacial bay seem now almost insuperable in this view, but I believe additional examination of the adjoining region will throw light upon this problem. J. B. Woodworth.

Cambridge, Mass., Oct. 12th, 1896.

Report of the State Geologist of New York for 1893—A Correction. In the 13th Annual Report of the State Geologist of New York for 1893, Prof. James Hall concludes the introduction to the study of the Brachiopoda. In glancing through its interesting pages one or two errors of citation are noted to which it is desired to call attention. On page 824 the genus *Orthorhynchula* is described and *O. linneyi* Nettelroth is cited as the type. This is not Nettelroth's species at all, but was originally described by Mr. U. P. James in 1881 as *Orthis (?) linneyi* (*Paleontologist*, No. 5, June 10, 1881, p. 41). At a later date, 1889, Mr. Henry Nettelroth described *Orthis linneyi* as a new species (*Kentucky Fossil Shells.* 1889, p. 41). It is a little curious that this should have occurred for Mr. James and Mr. Nettelroth were correspondents and the former sent his publications to the latter. It may be accounted for, perhaps, by the fact that the final revision of the "Kentucky Fossil Shells" was done by other hands than those of the author. The error in citation by Prof. Hall would have been more excusable if the four pages of errata at the end of Mr. Nettelroth's volume had not been printed. They must have been overlooked by Prof. Hall or Prof. Clarke. On the first page the error is pointed out and the correct reference to the first description of *O. linneyi* is given.

There is still another error in the authority given for *Zygospira Kentuckiensis* in the description to plate 40, p. 234. The species is credited to James. It should have been Nettelroth. Here again Nettelroth described as new a species that had been described 11 years before. In "The Paleontologist" No. 1, July 2, 1878, p. 7, Mr. James says under the head of *Zygospira modesta* var. *Kentuckyensis*: "The fossil for which this name is proposed, by the finder, Henry Nettelroth, Esq., of Louisville, Ky." etc. Notwithstanding this we find *Zygospira kentuckyensis* given as a new species by Nettelroth (Kentucky Fossil Shells p. 138) without any reference to a previous description. In this case the erratum is wrong for the species is there credited to Mr. James.

Lastly in the citation of authority for *Zygospira cincinnatiensis* in the description of plate 40, Prof. Hall gives Meek. It would be more correct to say "(James) Meek," for it was proposed by Mr. James and credited to him by Mr. Meek, in the Ohio Paleontology, (vol. I, p. 126).

J. F. JAMES, M. D.

Hingham, Mass., Sept. 14, 1896.

GEOLOGY AND MINING. A highly valuable article, which illustrates clearly the intimate relation between mining and theoretical geology, is contained in the October number of the "Zeitschrift für praktische Geologie," which has been published in Berlin by mining engineer Max Krahmann since 1893.

Under the title "Contributions to the origin of the Freiberg lead ore and the Erzgebirge tin veins" are published 36 pages of valuable notes which were found among the papers of the late Bergrath Dr. A. W. Stelzner, the celebrated Freiberg geologist. They discuss the important question of whether the ore deposits or fissure fillings derived their metallic contents through leaching of the adjacent rocks or from thermal waters which ascended from great depths.

Prof. Fridolin von Sandberger of Würzburg maintained the former view. He supported the "lateral secretion theory," which had already been advanced by him, by analyses of the mica found in the adjacent rocks, which mica, according to him, contains the gang metals as silicates, which are found where no leaching has taken place.

Stelzner opposed this theory and showed, in the case of the Freiberg gneiss, that its mica contained no metals, or, if present, that they were not primary silicates. Consequently the Freiberg ore deposits cannot have originated by leaching of the adjacent rocks. And hence also (and here lies the great question in practical geology) the chemical criteria proposed by Sandberger and whose application was vainly attempted at Pribram are unfortunately impossible of application at Freiberg and many other mining districts. This exploitation by means of chemistry, that is, the drawing of conclusions from the nature and leached or unleached condition of the rocks, must nevertheless remain the hope of the miner. Genetic relationships between ore deposits and enclosing rocks occur on every hand. It is only a question of their proper interpretation.

Herein lies the future of practical geology, and hence the great significance of these notes of Stelzner's, which are highly interesting in themselves, and are now accessible to anyone. Every mining man, geologist, mineralogist and chemist will find in them a fund of information and suggestion. F. M.

GYPSUM BEDS IN SOUTHERN ARIZONA. Extensive stratified deposits of gypsum occur in the Santa Rita range of mountains, near the northern end, about twenty miles southeast of Tucson and fifteen miles or less from the line of the Southern Pacific railway. The thickness of the series is estimated at not less than two hundred feet. The strata are nearly on edge and appear to form a part of a great series of sediments, shales and quartzites above the Lower Carboniferous limestone, which is largely developed in the Santa Rita mountains.

WM. P. BLAKE.

Arizona School of Mines, University of Arizona, November, 1896.

RECENT PUBLICATIONS.

I. Government and State Reports.

U. S. Geol. Survey, Bulletins. No. 123, A dictionary of geographic positions, Henry Gannett; No. 124, Revision of the American fossil cockroaches, with description of new forms, S. H. Scudder; No. 125, The constitution of the silicates, F. W. Clarke; No. 126, A mineralogical lexicon of Franklin, Hampshire and Hampden counties, Mass., B. K. Emerson ; No. 128, The Bear River formation and its characteristic fauna, C. A. White ; No. 129, Earthquakes in California in 1894, C. D. Perrine; No. 130, Bibliography and index of North American geology, paleontology, petrology and mineralogy for 1892-1893, F. B. Weeks; No. 131, Report of progress of the division of hydrography for the calendar years 1893 and 1894, F. H. Newell: No. 132, The disseminated lead ores of southeastern Missouri, Arthur Winslow; No. 133, Contributions to the Cretaceous paleontology of the Pacific coast: The fauna of the Knoxville beds, T. W. Stanton; No. 134, The Cambrian rocks of Pennsylvania, C. D. Walcott; No. 135, Bibliography and index of North American geology, paleontology, petrology and mineralogy for 1894, F. B. Weeks.

U. S. Geol. Survey, 15th Ann. Rept: Preliminary paper on the geology of the common roads of the United States, N. S. Shaler; The Potomac formation, L. F. Ward; Sketch of the geology of the San Francisco peninsula, A. C. Lawson: Preliminary report on the Marquette iron-bearing district of Michigan, C. R. VanHise and W. S. Bayley, with a chapter on the Republic trough, by H. L. Smyth; The general relations of the granitic rocks in the middle Atlantic Piedmont plateau, G. H. Williams; The origin and relations of central Maryland granites, C. R. Keyes.

U. S. Geol. Survey, 16th Ann. Rept. Pt. II:—Geology and mining industries of the Cripple Creek district, Colorado, Whitman Cross and

R. A. F. Penrose, Jr.; The geology of the road-building stones of Massachusetts, with some consideration of similar materials from other parts of the United States, N. S. Shaler; Economic geology of the Mercur mining district, Utah, J. E. Spurr, with introduction by S. F. Emmons; The public lands and their water supply, F. H. Newell; Water resources of a portion of the Great plains, Robert Hay. Part III:—Mineral resources of the U. S. for 1894, metallic products. Part IV:—Mineral resources of the U. S. for 1894, non-metallic products.

Illinois State Mus. Nat. Hist., Bull. II, 50 pp., 5 pls., Aug. 20, 1896. New species of Palæozoic invertebrates from Illinois and other states, S. A. Miller and W. F. E. Gurley.

Iowa Geol. Survey, vol. 5 (Ann. Rept. for 1895), 452 pp., 14 pls., 7 maps 1896. Geology of Jones Co., Samuel Calvin; Geology of Washington Co., H. F. Bain; Geology of Boone Co., S. W. Beyer; Geology of Woodbury Co., H. F. Bain; Geology of Warren Co., J. L. Tilton; Geology of Appanoosa Co., H. F. Bain.

Boletin del Instituto Geologico de México. Num. 3, 57 pls.: maps and sections, 1896. La geografia y la geologia de la peninsula de Yucatan, Carlos Sapper.

Alabama Geol. Survey, 164 pp,, 1896. Iron making in Alabama, W. B. Phillips.

U. S. Geol. Survey, Bull. 136, 124 pp., 28 pls., 1896. The ancient volcanic rocks of South mountain, Pennsylvania, Florence Bascom.

U. S. Geol. Survey, Div. of Hydrography, circular no. 5, 10 pp., Sept., 1896. Hydrographic surveys, F. H. Newell.

Geol. Survey of Ala., bull. 6, vii and 202 pp., 3 pls., 1896. A preliminary report on the upper gold belt of Alabama, W. M. Brewer; A general account of the character, distribution and structure of the crystalline rocks of Alabama and of the mode of occurrence of the gold ores, E. A. Smith; Notes on the microscopic characters of the Alabama crystalline or metamorphic rocks, G. W. Hawes; Notes on the microscopical character of certain rocks from northeast Alabama, J. M. Clements; Preliminary petrographic notes on some metamorphic rocks from eastern Alabama, A. H. Brooks.

Cal. State Mining Bureau, bull. 10, viii and 121 pp., Sept. 1896. A bibliography relating to the geology, palæontology and mineral resources of California, A. W. Vogdes.

Mo. Geol. Survey, vol. 9, Reports on areal geology, sheets 1-4; 420 pp. 4 maps, 25 pls., 1896. Areal geology and its relations to other geological work, C. R. Keyes; Report on the Higginsville sheet, Arthur Winslow; Report on the Bevier sheet, C. H. Gordon; Report on the Iron Mountain sheet, Arthur Winslow, Erasmus Haworth and F. L. Nason; Report on the Mine la Motte sheet, C. R. Keyes.

Ontario Bureau of Mines, 5th (1895) Rept., vii and 297 pp., 3 maps, 1896. Second report on the gold-fields of western Ontario, A. P. Coleman: Report on a section of the Height of Land region northeast of lake Superior, E. B. Borron.

II. Proceedings of Scientific Societies.

Bull. Amer. Geog. Soc., vol. 28, no. 2, 1896. The physical geography of New York state, R. S. Tarr.

Proc. Iowa Acad. Sci. for 1895, vol. 3, 230 pp., 15 pls., 1896. The Le Claire limestone. Samuel Calvin; The Buchan gravels, an interglacial deposit in Buchanan Co., Iowa, Samuel Calvin; Recent discoveries of glacial scorings in southeastern Iowa. F. M. Fultz; Some facts brought to light by deep wells in Des Moines Co., Iowa, F. M. Fultz; Recent developments in the Dubuque lead and zinc mines, A. G. Leonard; The area of slate near Nashua, N. H., J. L. Tilton; Note on the nature of cone-in-cone, C. R. Keyes; Two remarkable cephalopods from the upper Paleozoic, C. R. Keyes; Variation in the position of the nodes on the axial segments of the pygidium of a species of Encrinurus, W. H. Norton; A theory of the Loess, B. Shimek.

Jour. Western Soc. Engineers, vol. 1, no. 3, June, 1896. Notes about the geology and hydrology of the Great lakes, P. Vedel.

Jour. Elisha Mitchell Sci. Soc., vol. 12, pt. 2, 55 pp., 11 pls., 1896. Notes on the kaolin and clay deposits of North Carolina, J. A. Holmes: Origin of the peridotites of the southern Appalachians, J. V. Lewis; Monazite, H. C. Nitze.

Trans. Roy. Soc. Canada, 2d ser., vol. 1, 1895. On some advances in mineralogical chemistry, B. J. Harrington; Notes on some of the Cretaceous fossils collected during captain Palliser's explorations in British North America in 1857-60, J. F. Whiteaves; On some fossils from the Nanaimo group of the Vancouver Cretaceous. J. F. Whiteaves: On collections of Tertiary plants from the vicinity of the city of Vancouver, B. C., J. W. Dawson; The principal features and geology of the route of the proposed Ottawa canal between the St. Lawrence river and lake Huron, R. W. Ells and A. E. Barlow; Traces of the Ordovician system on the Atlantic coast, G. F. Matthew: Organic remains of the Little River group, No. IV, G. F. Matthew.

Proc. Ala. Indust. and Sci. Soc., vol. 6, pt. 1, 1886. Gold mining in Alabama, W. M. Brewer.

Jour. Western Soc. Engineers, vol. 1, no. 4, Aug.. 1896. Relics turned up in the drainage canal, Ossian Guthrie.

Proc. Amer. Acad. Arts and Sci., vol. 31, 1896. On the composition of the Ohio and Canadian sulphur petroleums, C. F. Mabery: The outline of cape Cod, W. M. Davis.

Bull. Philos. Soc. of Washington. vol. 12 (1892-94), xxix and 567 pp., 12 pls., 1895. The Mexican meteorites. J. R. Eastman: Geology of Chilhowee mountain. Tenn.. Arthur Keith; The origin of igneous rocks, J. P. Iddings: Determination of the dates of publication of Conrad's "Fossils of the Tertiary Formation" and "Medial Tertiary," W. H. Dall: The Moon's face: a study of the origin of its features, G. K. Gilbert: Relief maps, Marcus Baker: Mean density of the earth E. D. Preston.

III. Papers in Scientific Journals.

Science, Aug. 7. Current notes on physiography, W. M. Davis; Cinnabar and rutile in Montana, M. E. Wadsworth.

Science, Aug. 14. Paleontology as a morphological discipline, W. B. Scott.

Science, Aug. 21. A northern Michigan baselevel, C. R. Van Hise; Current notes on physiography, W. M. Davis; The "Kansan" glacial border, E. H. Williams, Jr.

Science. Aug. 28. An Ozark soil, O. H. Hershey: Impossible volcanoes, O. C. Farrington.

Jour. of Geol. July-Aug. Decomposition of rocks in Brazil, O. A. Derby; Italian petrological sketches, I, the Bolsena region, H. S. Washington; Drainage modifications and their interpretation, M. R. Campbell; Glacial studies in Greenland, IX, T. C. Chamberlin; Deformation of rocks, IV, C. R. Van Hise.

School of Mines Quart., vol. 17, no. 4, July, 1896. The genesis of the talc deposits of St. Lawrence Co., N. Y., C. H. Smyth, Jr.; Lecture notes on rocks, J. F. Kemp; Optical mineralogy, L. McI. Luquer.

Amer. Jour. Sci., Sept. Bearpaw mountains of Montana, W. H. Weed and L. V. Pirsson; Is the land around Hudson bay at present rising?, J. B. Tyrrell; Principles of North American pre-Cambrian geology, C. R. Van Hise, with an appendix on flow and fracture of rocks as related to structure, by L. M. Hoskins; Bethany limestone of the western interior coal-field, C. R. Keyes: Thickness of the Paleozoic sediments in Arkansas, J. C. Branner; Devonian of north Missouri, with notice of a new fossil. G. C. Broadhead; A visit to the Great Barrier reef of Australia, A. Agassiz.

Nat. Geog. Mag., Sept. The recent earthquake wave on the coast of Japan, E. R. Scidmore; Descriptive topographic terms of Spanish America, R. T. Hill.

Amer. Jour. Sci., Oct. Notes on some Mesozoic plants from near Oroville, Cal., W. M. Fontaine; On crystal measurement by means of angular coördinates and on the use of the goniometer with two circles, Chas. Palache; Note on recently discovered dikes of alnoite at Manheim, N. Y., C. H. Smyth, J.; The geology of Block island, O. C. Marsh.

Technology Quarterly, vol. 9. nos. 2-3, June-Sept., 1896. Englacial drift, W. O. Crosby.

Science, Sept. 4. Current notes on physiography, W. M. Davis.

Science, Sept. 11. Geological myths, B. K. Emerson; Commercial mica in North Carolina: the story of its discovery, F. W. Simonds.

Science. Sept. 18. Section E of the A. A. A. S., W. N. Rice.

Science, Sept. 25. Current notes on physiography, W. M. Davis.

Science, Oct. 2. Geology in the colleges and universities of the United States, F. W. Simonds.

Science, Oct. 9. The Cornell expedition to Greenland. R. S. Tarr: Current notes on physiography, W. M. Davis.

Science, Oct. 16. The geology of Block island, Arthur Hollick.

Science, Oct. 23. Current notes on physiography, W. M. Davis.

Science, Oct. 30. Geology in the colleges of the United States, L. W. Chaney, Jr.

Amer. Nat., Oct. Fresh relics of glacial man at the Buffalo meeting of the A. A. A. S., G. F. Wright; Structure of Uintacrinus, C. R. Keyes.

Jour. of Geol., Sept.-Oct. Drainage modifications and their interpretation, pt. 2, Criteria for determining stream modification, M. R. Campbell; The monchiquites or analcite group of igneous rocks, L. V. Pirsson; The Queen's River moraine in Rhode Island, J. B. Woodworth and C. F. Marbut; The principles of rock weathering, G. P. Merrill.

Nat. Geog. Mag., Oct. The economic aspects of soil erosion, N. S. Shaler; Ice-cliffs on the Kowak river, J. C. Cantwell.

Canadian Rec. of Sci., vol. 9, nos. 1 and 2, 1896. Description of a supposed new genus of Polyzoa from the Trenton limestone at Ottawa, L. M. Lambe; Anhydrite in Ontario, W. Nicol; Review of the evidence for the animal nature of Eozoön canadense, J. W. Dawson; On a new alkali hornblende and a titaniferous anhydrite from the nepheline-syenite of Dungannon, Hastings Co., Ontario, F. D. Adams and B. J. Harrington.

Utah Univ. Quarterly, vol. 2, no. 2, June, 1896. The Great Salt lake; past and present, J. E. Talmage; Some of the crystalline rocks of Salt Lake and Davis counties, Utah, W. D. Neal.

Amer. Jour. Sci., Nov. Missourite, a new leucite rock from the Highwood mountains of Montana, W. H. Weed and L. V. Pirsson; The Silveria formation, O. H. Hershey; Local deformation of strata in Meade county, Kansas, and adjoining territory, Erasmus Haworth; Amphibian footprints from the Devonian, O. C. Marsh; Geology of Block island, O. C. Marsh.

Amer. Nat., Nov. Fossils and fossilization, L. P. Gratacap.

IV. Excerpts and Individual Publications.

Notes on Palæozoic Crustacea, No. 5.—Carboniferous trilobites from Missouri, A. W. Vodges. Proc. Cal. Acad. Sci., 2d ser., vol. 6, pp. 197-198, June 24, 1896.

On the existence of pre-Cambrian and post-Ordovician trap dikes in the Adirondacks, A. P. Cushing. Trans. N. Y. Acad. Sci., vol. 15, pp. 248-252, Sept., 1896.

On pearceite, a sulpharsenite of silver, and on the crystallization of polybasite, S. L. Penfield. Proc. Colo. Sci. Soc., 15 pp., read Apr. 6, 1896.

The San Miguel formation, Whitman Cross. Ibid., 7 pp.; read Sept. 7, 1896.

Igneous rocks of the Telluride district, Colorado, Whitman Cross. Ibid., 10 pp.; read Sept. 7, 1896.

Catalogue of meteorites in the collection of the American Museum of Natual History, to July 1, 1896, E. O. Hovey. Bull. Amer. Mus. Nat. Hist., vol. 8, pp. 149-155; author's edition, July 3, 1896.

The Sioux quartzite and certain associated rocks, S. W. Beyer. Iowa Geol. Survey, vol. 6, pp. 67-112, pl. 5, 2 maps, 1896.

Lead and zinc deposits of Iowa, A. G. Leonard. Iowa Geol. Survey, vol. 6, pp. 9-66, pl. 1-2, 1896.

A handbook of rocks, for use without the microscope, J. F. Kemp. vii and 176 pp., New York, 1896; published for the author.

A preliminary report upon the Florida parishes of east Louisiana and the bluff, prairie and hill lands of southwest Louisiana, W. W. Clendenin. Pp. 163-257, 1896.

Notes on some specimens of minerals from Washington heights, New York city, E. O. Hovey. Bull. Amer. Mus. Nat. Hist., vol. 7, pp. 341-342.

Structural details in the Green Mountain region and in eastern New York, T. N. Dale. U. S. Geol. Survey, 16th Ann. Rept., pt. 1, pp. 543-570, 1896.

Principles of North American pre-Cambrian geology (with an appendix on flow and fracture of rocks as related to structure by L. M. Hoskins), C. R. Van Hise. U. S. Geol. Survey, 16th Ann. Rept., pt. 1, pp. 571-874, pls. 108-117, 1896.

Notes on the osteology of the White River horses, M. S. Farr. Proc. Amer. Philos. Soc., vol. 35. pp. 147-175, pl. 13; reprinted Sept. 7, 1896.

The Jura of Texas, Jules Marcou. Proc. Boston Soc. Nat. Hist., vol. 27, pp. 149-158, Oct., 1896.

The genetic relations of certain minerals of northern New York, C. H. Smyth, Jr. Trans. N. Y. Acad. Sci., vol. 15, pp. 260-270, Sept. 25, 1896.

The physical features of Missouri, C. F. Marbut. Mo. Geol. Survey, vol. 10, pp. 11-109, pls. 1-11, 1896.

The formation of the Quaternary deposits of Missouri, J. E. Todd. Mo. Geol. Survey, vol. 10, pp. 111-217, pls. 12-23, 1896.

The glacial deposits of Indiana, Frank Leverett. Inland Educator, pp. 24-32, Aug., 1896.

V. *Proceedings of Scientific Laboratories, etc.*

Univ. of Cal., Bull. Dept. Geol., vol. 2, no. 1, pp. 1-92, pls. 1-2, May, 1896. The geology of point Sal, H. W. Fairbanks.

Field Columbian Mus. Zool. ser., vol. 1, no. 5, pp. 101-106, pls. 14-15, June, 1896. On the skeleton of Toxochelys latiremis, O. P. Hay.

Bull. Dept. Geol. Univ. of Cal., vol. 2, no. 2, pp. 93-100, pl. 3, Aug., 1896. On some Pliocene Ostracoda from near Berkeley, Frederick Chapman.

Univ. of Wyoming, Sch. of Mines, Petroleum series. bull. 1, 47 pp., June, 1896. The geology and technology of the Salt Creek oil field, W. G. Knight; The analysis of the Salt Creek petroleum, E. E. Slosson.

Field Columbian Museum, Zool. ser., vol. 1, no. 5, pp. 99-106, pls. 14-15, June, 1896. On the skeleton of Toxochelys latiremis, O. P. Hay.

PERSONAL AND SCIENTIFIC NEWS.

The Academy of Natural Sciences of Philadelphia has conferred the Hayden Memorial Geological award for 1896 on Prof. Giovanni Capellini of the University of Bologna.

The Geological Society of America will hold its [illegible] winter meeting in Washington, D. C., beginning Tuesday, [illegible]cember 29, 1896. The Council will meet on that day at [illegible] a. m., and the Society will be called to order at 10 a. m. [illegible] building in which the meetings are to be held has not yet [illegible] announced. Willard's hotel is selected as headquarters.

The Transvaal gold deposits, traced and surveyed in [illegible] vicinity of Johannesburg, are estimated by Dr. George F. B[illegible] [illegible] to contain $[illegible] of the precious metal, or near[illegible] much as the entire volume of gold coin in the world. [illegible] [illegible] of great width and depth, outcrops along a [illegible] course of [illegible] miles. It is being mined at the rate [illegible] $[illegible] year, [illegible] exceeding the highest ann[illegible] [illegible] of California.

The Academy of Science, St. Louis. At the [illegible] of the Academy of Science of St. Louis, on the evening [illegible] [illegible]

[illegible]

Leverett, and he ably sets forth the evidence of successive stages or epochs of the Glacial period. The average thickness of the drift in northern Indiana is estimated to be 250 feet, or perhaps even more than 300 feet. W. U.

GEOLOGY IN THE COLLEGES AND UNIVERSITIES OF THE UNITED STATES.

Under this title, Mr. T. C. Hopkins contributes a valuable statistical paper of 54 pages in the report of the Commissioner of Education for the year 1893-94, which was published and distributed a few months ago. Definite statements are given concerning the time devoted to geological instruction, the several courses offered to students, opportunities for field work, and the laboratory, museum and library equipment, in each of the 378 collegiate institutions of the United States which give instruction in this science. In twenty-four colleges, geology is taught by the president; and in seven colleges by a lady professor or instructor. During the year of this report, sixty-eight graduate students were making a specialty of geology, including eighteen in Johns Hopkins University, thirteen in the University of Chicago, and eleven in Harvard University. W. U.

GEOLOGIC ATLAS OF THE UNITED STATES.

Seven new folios of this admirable atlas, with descriptive text, have been recently issued, as follows:

21. Pikeville folio, in Tennessee, by Charles Willard Hayes.
22. McMinnville folio, in Tennessee, also by Mr. Hayes.
23. Nomini folio, in Maryland and Virginia, by N. H. Darton.
24. Three Forks folio, in Montana, by A. C. Peale.
25. Loudon folio, in Tennessee, by Arthur Keith.
26. Pocahontas folio, in Virginia and West Virginia, by Marius R. Campbell.
27. Morristown folio, in Tennessee, by Arthur Keith.

Each folio maps an area bounded by arcs of a half degree, excepting that of Three Forks, which measures one degree on each side. The scope of the maps and descriptions, including ample details of the topography, local formations, and material resources, was stated in the AMERICAN GEOLOGIST for last March (vol. XVII, pp. 177–179), with notes of the previous twenty folios. W. U.

ACCORDING TO MR. S. F. EMMONS there are in the Black Hills three types of gold deposits: The Homestake type of deposit, the siliceous gold ores of the Cambrian, and the placer deposits. The first occur in sheets often several hundred feet wide along a mineral-bearing zone, which is mostly controlled by the Homestake company, and is now worked to a vertical depth of 800 feet. The placer deposits are partly ancient or fossil placers at the base of the Cambrian (Middle

Cambrian, and not Potsdam sandstone, as it has hitherto been called), and modern placers along present stream beds, resulting in part from the disintegration of the older placers. The so-called siliceous gold ores occur in the remnants of Cambrian beds and included porphyry bodies in the elevated region around Grey's peak and Bald mountain, to the west of the Homestake belt. The ore bodies are siliceous replacements of certain beds in the upper and lower parts of the formation near eruptive sheets or dikes, which have been mineralized from certain north and south cracks or fissures—locally called "verticals"—which traverse both sedimentary beds and eruptive sheets. The ores are finely disseminated pyrite, generally oxidized with gold, either free or combined with tellurium. The ore bodies are of great longitudinal extent, having been traced continuously in the Golden Reward main for many thousand feet; in some cases they are twelve feet thick and more than a hundred feet wide. They give promise of important future developments.

NEW YORK ACADEMY OF SCIENCES; SECTION OF GEOLOGY AND MINERALOGY, OCTOBER 19, 1896.

The first paper of the evening was by Arthur Hallick, entitled *Geological Notes; Long Island and Block Island.* Previous investigations on Staten island, Long island, Martha's Vineyard and Nantucket have proved a unity of geologic conditions throughout, and it was confidently expected that a careful examination of Block island would show this also to be part of the same general series.

During the past summer the island was visited and proofs were obtained of drift phenomena identical with those of the other localities. A collection of fossils was made which demonstrated the former existence of Cretaceous strata on the island. The material collected consisted of plant remains, imperfectly preserved, and of mollusks in a good state of preservation. These latter were identified by Prof. R. P. Whitfield, and the list numbers ten species, in addition to fragmentary remains of perhaps half a dozen more. They are typical of the lower green-sand marl and were found as drift material in the moraine, under the same conditions in which similar fossils have been found in the other localities mentioned. It was also thought advisable to again visit the eastern end of Long island in order to ascertain whether more definite fossil remains could be found on Montauk point, where imperfectly preserved fossils had been discovered on a previous occasion. Here also well-preserved mollusks were found, likewise identified by Prof. Whitfield, who has furnished a list of five species and two genera, in addition to which a number of imperfect specimens, representing about five additional species. The discoveries were highly satisfactory, and

furnished the proof that had been confidently expected. The specimens collected were exhibited.

The second paper was by Prof. J. F. Kemp, *On the Glacial or Post-Glacial Diversion of the Bronx River.* The speaker showed that the Bronx river from its source to Williamsbridge, follows an old valley, excavated in limestone. This valley continues from a point below Williamsbridge to its end, on the sound opposite Randall's island, and there is a depression the entire distance. Just below Williamsbridge, however, the river turns from its old valley and breaks through a ridge of enclosing gneiss on the east. It has excavated a gorge about 70 feet deep, with large fresh pot-holes remaining on the sides, respectively at altitudes of 20 and 50 feet above the stream. The maximum hight of the divide between the present channel and the older one is only 10 to 15 feet. The speaker found difficulty in accounting for the diversion, in that no barrier of gravel or other deposit is visible along the line of the old channel, which would turn the stream from this across the high ridge in which is the gorge. The freshness of the potholes indicated that the stream had cut the gorge during glacial times and since then. He therefore referred the diversion to the ice of the continental glacier, a lobe of which must have filled the earlier channel. It is probable that the early excavation was done by a subglacial stream, heavily loaded with sediment.

The third paper of the evening was by D. H Newland, on the *Eclogites of Bavaria.* The speaker described the extent, and mineralogy of the rocks and his attempts to discover their unmetamorphosed originals. Chiefly on chemical analysis he was led to infer that they had been original diabases or gabbros.

The section of Geology and Mineralogy held its regular monthly meeting Nov. 16, Prof. Albert H. Chester in the chair, as chairman *pro tem.* The first paper was by Dr. E. O. Hovey, entitled "On a deep well-boring at Key West, Fla." Dr. Hovey described the geological section uncovered by the well for a depth of more than 2,000 feet. A number of microscopic organisms were obtained. It proved somewhat difficult to identify the geological horizons, but without much doubt the well penetrated a considerable distance into the Miocene. In the limestone many grains of quartz, possibly of secondary depositions were met, and also rolled grains of quartz, doubtless in the nature of sand. Dr. Hovey comments on the significance of the phenomena, and expressed his obligations to professor Alexander Agassiz, from whom the samples had been obtained. The paper will appear in full in an early number of the Bulletin of the American Museum of Natural History.

Prof. A. J. Moses then exhibited a number of new mineralogical instruments which had recently been sent from Europe.

They included a little adjustable dark room which could be fitted to a Fuess No. 2 goniometer, so that crystals could be measured by daylight. Perfect signals could be obtained even in a well lighted room. The instrument is called the Traube Verdunklungsvorrichtung. The universal rotation attachment for mineralogical microscopes which has been invented by professor Klein of Berlin, for measuring the angle of the optic axes of microscopic crystals was also shown. Klein's new rotation apparatus for the orientation of thin sections was next described. The new attachment, which can be adjusted to a Fuess goniometer No. 2, for measuring the optic axes, was shown and an opportunity was afforded to test it by actual experiment. The von Federow mica wedge (glimmerkeil) which consists of a series of superposed ¼ undulation mica plates, and is used for all the purposes of a quartz wedge, concluded the paper.

The third paper was by Mr. A. Chester Beatty, entitled "The Minerals of the Elkhorn Mine, Montana." Mr. Beatty exhibited, with comments, a remarkable series of calamine, smithsonite, native silver and other minerals.

Professor A. H. Chester presented a paper on the new discovery of the brassy, micaceous mineral which seems, from the only analysis, to be chalcodite, and which has been found in a quarry at Rocky Hill, New Jersey, He also exhibited a remarkable series of rutile from Graves mountain, Georgia.

G. F. Kunz described a new meteorite from Guatemala, and read a joint paper by Dr. Hillebrand and himself upon a new discovery of prosopite in Utah. He read also a joint paper by Morris Heights, and by Prof. J. F. Kemp, who remarked on the interest attached to this association of minerals, because of the difference of opinion prevailing among geologists, as to whether they indicate contact metamorphism or merely regional metamorphism.

The last paper of the evening was by Prof. J. F. Kemp, entitled "Exhibition of interesting minerals collected during the summer." The speaker exhibited covellite, goslarite, enargite, chalcocite and tetrahedrite from Butte, Montana, which were exceptionally fine crystals. Remarkably large prisms of andalusite from the Black Hills were also shown, and zircons and allanite from Mineville, Essex county, New York.

A collection of chalcodite from a quarry near Reading, Pennsylvania, was exhibited by Mr. Roebling of Trenton, New Jersey, in connection with the paper by Prof. Chester. The Academy then adjourned to inspect the minerals.

J. F. KEMP, *Sec.*

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ERRATA.

On page 132, 10th line, for "latter" read former.

On *Plate XI*, change the explanations so as to read in the following order downward:

CUT SURFACE SHOWING OXIDATION.

EDGE VIEW.

SIDE VIEW.

Page 179, read *tenuifilum.*

Page 217, fifth line, for Prof. E. O. Hovey, read Dr. H. C. Hovey.

Page 268, third line, for ½ inch, read 1 inch.